Preparing Highly Competent Electronics Technicians in Manufacturing, Communications & Information Technologies. A Project Proposal to the NSF Advanced Technological Program from the University of Puerto Rico Resource Center for Science & Engineering; October, 2000.

I. Results from Prior NSF Support:

The Resource Center for Science and Engineering strategy for the 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 (SMET) education, through a partnership between 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. The goal of the reform is to optimize the teaching and learning of SMET at all levels of the educational system, through a coherent and articulated strategy, to achieve high levels of student performance and prepare the highly competent professionals required to meet the need for human resources in these fields at the regional as well as national level.

The systemic reform in Puerto Rico is spearheaded through three major initiatives: the PR-Statewide Systemic Initiative (PR-SSI), the Collaborative for Excellence in Teacher Preparation (PR-CETP), and the Puerto Rico Louis Stokes Alliance for Minority Participation (PR-LSAMP), which are all co-funded by the National Science Foundation (NSF) and local institutions on the Island. The coordination of these initiatives by the RCSE has enabled their articulation as integral 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 which is critical for achieving systemic change. The effective articulation of these initiatives as a single systemic reform under the RCSE, and the achievements attained, have been recognized by national experts as models of excellence that are transferable to the United States mainland.

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

The central goal of the PR-SSI is to transform the K-12 science and mathematics educational system to provide all K-12 students with high quality, standards-based education. The PR-SSI has focused on developing and disseminating 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 the year 2000, the major accomplishments of the PR-SSI are: (1) the elaboration and dissemination of educational standards for K-12 science and for mathematics aligned with those of the National Council of Mathematics Teachers (NCTM) and the National Research Council (NRC), the AAAS Project 2061 Benchmarks, 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 model 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 which are integrated into the teaching-learning process; (5) the development of a whole-school approach to implement standards-based curricula and empower schools to transform the teaching/learning culture; (6) the establishment of thirty (30) school-based Regional Professional Development and Dissemination Centers geographically distributed throughout the Island to scale-up the reform, where teams of exemplary teachers and university faculty offer academic and technical assistance; (7) the creation of a Three-Tiered Student Assessment Model to measure the progress of the reform which includes assessment strategies that are aligned with the NAEP and TIMSS; (8) the development of a collaborative project with the New York City School System to adopt the PR-SSI reform in that

system; (9) the 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. The PR-SSI, and particularly achievements 9 through 11, has served as the foundation for the development of the Puerto Rico Collaborative for Teacher Preparation (PR-CETP), co-funded by the NSF, a large scale systemic reform which is promoting the alignment of the major teacher preparation programs on the Island with the PR-SSI reform. In the year 2000, the PR-SSI is scaling-up the reform to reach a total of 725 schools, close to 50% of all schools in the Island's public school system.

Due to its success as a systemic reform, the PR-SSI has become one of eight of the SSI projects at the national level to be co-funded by the NSF for Phase II. 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. One of the critical indicators of the effectiveness of the PR-SSI is the achievement level of graduating students in the College Board Exam, which has a 0.87 correlation with the SAT Math test. Students who had been in the PR-SSI during 6 years outperformed private school students in the Math Reasoning Test by 58 points, and those who had been in PR-SSI for three years outperformed non-PR-SSI public school counterparts by 32 points.

B. PR Louis Stokes Alliance for Minority Participation (PR-LSAMP)- Phase I (HRD 9153687) 07/91-12/96; Average annual funding: $1M from NSF + $1M local matching per year; **Phase I HRD (9623943) 11/96-10/2001: NSF=$880,000 and cost sharing $1.48 M.**

The Puerto Rico Louis Stokes Alliance for Minority Participation (PR-LSAMP) was established in 1991 through a cooperative agreement with the NSF as an alliance of the University of Puerto Rico (UPR) Resource Center for Science and Engineering and the major higher education

institutions on the Island that offer baccalaureate degrees in science, mathematics, engineering, and technology (SMET). The goal is to increase the quantity and quality of underserved low-income/first-generation college students who successfully complete a baccalaureate degree in SMET, as well as those who enroll in graduate programs in these fields. The main strategy of the PR-LSAMP to achieve this goal has been to improve the effectiveness and efficiency of undergraduate SMET education by transforming the teaching/learning culture to ensure higher levels of learning through a student-centered approach to teaching, supported by a more nurturing environment that promotes student retention. In achieving this goal, the PR-LSAMP has developed a systemic approach to institutional change which articulates the transformation of the key components of the undergraduate education enterprise as part of the broader K-16+ continuum throughout the Island. During the past nine years, PR-LSAMP institutions have increased the number of BS degrees awarded in SMET fields from 1,709 to 2,771, a 62% increment. During this same period of time, SMET undergraduate enrollment has almost doubled, from 12,572 to 23,476.

One of the central issues in the undergraduate SMET reform is to improve the academic performance of all students, lowering attrition and failures rates and promoting high levels of learning to ensure the quality of BS graduates. The main strategy of the PR-LSAMP to improve teaching and learning has been to revise the SMET curriculum by incorporating research based teaching strategies focusing on active and interactive learning through inquiry and discovery processes. Efforts have concentrated on the revision of a set of SMET courses that evidence the highest attrition and failure rates. One of the key indicators developed by the PR-LSAMP to measure institutional efficiency in the teaching-learning process is the Index of Course Efficiency (ICE) which represents the average number of times students must take a SMET course to satisfactorily pass it. Faculty members who have revised the content of the courses to emphasize key concepts to

stress depth of understanding and to incorporate teaching strategies that promote inquiry-based and discovery activities, have demonstrated a significant improvement in reducing attrition and failure rates, thus improving the ICE index. On the average, the ICE for SMET courses at three PR-LSAMP institutions was reduced from 2.43 to 1.79**.**

Other metrics used by PR-LSAMP to measure the effectiveness and efficiency in SMET programs are graduation and retention rates, and the average number of years to complete a BS degree. In addition to the significant increment in enrollment and degrees in SMET disciplines, the success of the systemic reform of SMET education is evident also through the following indicators:

- The average graduation rate for UPR institutions in science and mathematics increased from 46% to 62%, while in Engineering it rose from 58% to 81%. The average graduation rate in private institutions increased from 49% to 55.3%.
- Graduates from PR-LSAMP institutions in 1997 (2,759) accounted for 25% of the degrees awarded to Hispanics nationwide that year (11,180) – Source: NSF Division of Science Resources Studies.
- Seventeen percent (17%) of the Hispanics that obtained a Ph.D. in a natural science field nationwide between 1993-98, received their BS degree from a PR-LSAMP institution (203 out of 1,169). Eleven percent (11%) of the Hispanics that obtained a Ph.D. in Engineering nationwide between 1993-98, received their BS degree from a PR-LSAMP institution. The number of students who go on to complete a PhD in a SMET field at UPR-Río Piedras is one in ten, a number that puts the UPR among the top performers in the nation.

II. The need to strengthen advanced technological education in Puerto Rico

This proposal seeks to strengthen advanced technological education as a fundamental component of the systemic reform of science, mathematics, engineering and technology (SMET)

education spearheaded through the RCSE pipeline strategy. The central goal of the Puerto Rico Advanced Technological Education Project (PR-ATE) is to improve the quality of education for preparing professionals in the fields of electronics in manufacturing and communications/information systems, particularly underserved, minority students. Improved educational quality and opportunities in the high tech -industry is a central need that must be addressed to strengthen economic growth at the local level as well as the national level. Puerto Rico is currently embarked in the development of a Technology Corridor to attract high technology companies, and promote the establishment of incubators and centers of excellence to accelerate its economic growth and competitiveness. A coalition of government, academia and industry has created a Science and Technology Policy to transform the Island's economy into a knowledge-based/skilled workforce economy. Two of five key areas for the development of the high technology industry envisioned in this policy are Manufacturing, and Communications and Information Technologies. Therefore, technological education on the Island needs to focus on these areas to meet the needs of high-tech industries in Puerto Rico, as well as the mainland.

During the past five years, a concerted effort has been carried out to strengthen education in fields related to high technology through the Caribbean Basin Local Partnership in High-Technology, a School to Work Program (STWP) sponsored by the US Department of Education. The goal of the STWP is to ensure a smooth transition between school and work by: 1) increasing academic and occupational performance to globally competitive levels; 2) making the learning process more interesting and relevant for students; 3) encouraging all students to pursue at least two years of postsecondary education or additional training; and 4) developing students' appreciation towards the need for lifelong learning. The STWP, along with the overall systemic educational reform in SMET, provide the foundation on which to build the effort to address the specific educational needs in the

field of electronics. Through the present proposal to the NSF ATE Program, an alliance of organizations, including those in the STWP, address the educational needs posed by the Island's economic strategic development plan by enhancing advanced technological education in the field of electronics with emphasis on manufacturing and communications and information technologies. The thrust of this effort is to strengthen the alignment of the teaching and learning process in electronics education programs, from the secondary to the undergraduate level at participating institutions, and the national standards of excellence in electronics education established by the Electronics Industries Foundation. The primary components of this project that will promote the achievement of the educational standards are: 1) curricular enhancement to improve conceptual learning through the integration of WWW/CD-ROM based interactive modules; 2) teacher and faculty enhancement in teaching methods, technology and advanced content knowledge in electronics; and 3) establishment of technical experiences for students, teachers and faculty which link learning in the classroom to industry.

III. Partners in the PR-ATE Project

UPR as Major Hispanic University for SMET

From 1993-98, 239 PhDs in SMET were conferred to BS graduates from PR, 96% of these from UPR campuses. In 1998, NSF reports that a total of 88 PhDs in SMET were conferred that year to Puerto Ricans at the national level, representing 25% of the doctoral degrees awarded to Hispanics nationwide.

The partners of the PR-ATE include three postsecondary institutions involved in are all campuses of the University of Puerto Rico (UPR) system which is the main producer of Hispanic baccalaureates who pursue graduate degrees in science, mathematics and engineering in the United States. The academic programs in electronics at these institutions share the goal of strengthening curricular offerings to ensure that graduates are well prepared to serve the high-tech-industry in the field of manufacturing as production and repair technicians for machine systems (electrical, hydraulic, and pneumatic) and in

the field of information technologies as specialists in network and communications systems and digital circuits. Over 95% of the graduates are placed in jobs related to high-tech industry, yet graduates need more advanced knowledge and skills to qualify for expanding, higher level positions requiring more advanced knowledge such as research assistants for R& D laboratories, area coordinators and group leaders, and supervisors of data communication networks and computer centers.

The higher education partners in the **PR-ATE** project are: 1) The UPR at **Aguadilla (UPR-A)**, the lead institution in the proposal, a two-year institution located in the western coast of the Island , which offers an AD in Electronics Technology and recently started to offer four year degrees in the fields of Science in Quality Control in Manufacturing and Electronics Engineering Technology. UPR-A has strong links with the high-tech sector serving as a training center in PLC, pneumatics, mechanics, and sensors; 2) The UPR at **Bayamón (UPR-B)**, a four-year institution located in the northern region of the Island, close to the San Juan metropolitan area, offers an AD in Electronics Technology and a BS in Electronics Engineering Technology. UPR-Bayamón has developed a specialized area in computer electronics, and is establishing the only network laboratory on the Island to support R&D with capabilities in protocol analysis, troubleshooting and traffic generation and monitoring; and 3) the **UPR at Humacao (UPR-H)** a four year institution located in the eastern coast of the Island, which offers an AD in Electronics Technology and a BS in Physics Applied to Electronics. Faculty at UPR-H are doing research in material science films in collaboration with the University of Pennsylvannia through an NSF funded Collaborative for Integration of Research and Education (CIRE) grant. UPR- Aguadilla and Humacao are major partners in the School to Work Program (STWP) and all three campuses are participating in the PR-LSAMP alliance. Through their participation in the PR-LSAMP alliance, the faculty from these

institutions have participated in the curricular revision of the introductory level science and mathematics courses, and in the faculty development offerings in the integration cooperative groups and inquiry-based teaching strategies, and technologies such as graphing calculators into the curriculum. Students from these institutions have benefited from undergraduate research experiences in SMET, peer mentoring, and from the Awards for Excellence to assist them in completing an undergraduate degree.

Twenty six (26) **secondary public schools** from the Islands'public educational system are joining the PR-ATE, which serve 16,000 students, 65% of which come from families below the poverty level. Of these, 21 are academic schools and five are in the Tech-Prep Program of the PR Department of Education. Seventeen of these schools are currently participating in the PR-SSI reform to implement the standards-based science and mathematics curriculum for all students. These schools are located close to the three postsecondary institutions in PR-ATE and have strong collaborative ties with them through the STWP. A group of **high-tech industries**, including several that are currently partners in the STWP, will join the PR-ATE project. Among the industry partners are: Allergan Medical Optics; Edward Life Sciences-Baxter; Solectron; Dual Lite; Hewlett Packard; Intel of Puerto Rico; Medtronic Medrel; Novartics Ex-lax; Sensormatic Electronics; R.D. Medical; Danbury Pharmaceutical; Smart Modular Technologies; McNeil Laboratories; Life Savers Mfg Inc.; Combe Products; Heyer Schulte; Centennial; Colorcon, PR, Inc., Symmetricom; and Schein Pharmaceutical. (see letters of collaboration in Appendix).

The **Resource Center for Science and Engineering (RCSE)** will serve as the grantee institution for the PR-ATE, to expedite the full collaboration of the diverse institutions in this endeavor, and to provide technical assistance and guidance in the design of and implementation of curricular modules and professional enhancement components. The RCSE, established in 1980 by

the UPR Central Administration, is a consortium of the main postsecondary educational institutions in Puerto Rico and the PR Department of Education, and serves as the umbrella organization for the statewide reform of science, mathematics and technology at all levels of the educational continuum. Throughout its 20 years of operations in partnership with NSF, the RCSE has developed multiple initiatives which are tightly articulated to transform K-graduate level education and promote high levels of excellence and achievement for all students. These systemic initiatives which span the K-graduate educational levels, all share a common vision of the educational process which aims to promote the lifelong learning capacities of students by engaging them in active inquiry experiences that require depth of conceptual understanding, integration of knowledge across disciplines, collaborative learning, and the ability to apply conceptual knowledge in real world problem solving. The RCSE has also been the site for the development of the STWP. As the grantee institution, the RCSE provides the core infrastructure which underlies these initiatives, ensuring the interconnections and close articulation of efforts as a coherent strategy to achieve the synergy of the K-16+ reform.

By articulating the development of the PR-ATE program with ongoing systemic reform initiatives, the RCSE will ensure the transfer of the best educational practices developed and sharing of the available expertise and resources. The multiple initiatives undertaken by the RCSE, including the STWP and the PR-SSI and PR-LSAMP (see description in Prior Results section), will provide a foundation on which to build the **PR-ATE** Project, taking advantage of the alliances established among multisectorial partners and the common understanding of the need to integrate academic learning experiences with on-site experiences that strengthen the development of work-

Major Partners in PR-ATE

- **UPR at Aguadilla**
- **UPR at Bayamón**
- **UPR at Humacao**
- **Secondary schools**
- **Major industries in electronics-manufacturing and telecommunications**

related knowledge and skills.

The **PR-ATE** will contribute to excellence in electronics education beyond the current efforts of the STWP by strengthening curricular offerings, faculty preparation and project based learning experiences in specific areas within the field of electronics, which the STWP does not address. Whereas the STWP mainly addresses the development of broad skills required for employability, such as effective communication, computer literacy, decision-making, problem solving, teamwork and numeracy, the **PR-ATE** will focus on more specialized content and skill areas directly applicable to the fields of electronics. The STWP has opened the doors for collaboration between schools, universities and industry, and has promoted the successful development of opportunities for incorporating work related experiences as part of the academic programs, including the integration of work-related content into the curriculum as well as on-site opportunities for students to learn about work, such as career awareness activities, industry tours, job shadowing, job rotation, mentoring, and others. As part of the STWP, representatives from sixteen industries participated in a Curriculum Committee to establish the employability skills required for entry-level positions in high tech industries and for incorporating the SCANS. These standards were used to design 68 instructional modules in the following academic disciplines: Spanish, English, Science, Mathematics, Social Studies, and Electronics; to develop the Academic/Research Modules on Industrial Production Processes, job shadowing and internship experiences, and the development of high tech centers to provide students with career exploration activities in the field of high-tech. The Puerto Rico Department of Education contributed $1 million through Goals 2000 funding to establish High Technology Centers in five of the STWP schools to strengthen the development of specialized skills.

IV. Goals and Objectives

The central goal of this proposal is to strengthen the preparation of underserved students in

the field of electronics at the secondary, associate and baccalaureate degree levels in Puerto Rico and the mainland, to enhance the performance of graduates as future employees of the high technology sector in manufacturing and information technologies. The specific areas in which the PR-ATE will strengthen technological education have been selected through an institutional self-assessment process undertaken by a team of electronics faculty representing the different participating precollege and postsecondary institutions in this endeavor, coordinated by the RCSE. The team developed an instrument to gauge the alignment of the curriculum of secondary school and undergraduate programs with the national skills standards for the field of electronics and the institutional profile for graduates to meet employment requirements, to identify the specific areas of need to strengthen the quality of the academic offerings. The main criteria for the selection of priority areas were based on: 1) evidence of learning difficulties by students; and 2) areas that were underdeveloped or need strengthening in the curricular offerings.

The team reached a general consensus on the areas of needs and strategies for developing a unified and collaborative approach for participation of all institutions, that will facilitate the sharing resources, learning experiences and developments. The needs assessment resulted in the identification of the following main areas of need as priorities to be addressed through the PR-ATE Project:

Thematic Areas	National Electronic Skills Addressed
1. Mathematics applied to electronics (general)	Foundation for mastering skills
2. Safety	A.02, C.07
3. How to use and interpret technical manuals and data books	A.07
4. Technical drawing	A.08
5. Inductors and capacitors	B.14, B.21, C.08, C.11, C.15, C.18, C.21, C.27, E.17
6. Magnetism	B.06, C.04, C.06, E.29

7. Basic Troubleshooting	A.03, B.10, B.13, B.20, B.23, C.10, C.13, C.17, C.20, C.23, C.26, C.29, C.32, D.08
8. Diodes and Transistors	D.02, D.06, D.12
9. Sensors	D.09, D.10
10. Polyphase Circuits	C.30, C.31
11. Sequential Circuits	F.11, F.14,F.17
12. Demultiplexer, multiplexer, decoder, encoder	F.22, F.30
13. Converters: Analogue to digital, digital to analogue	F.24
14. Intermediate Troubleshooting	D.11, D.14, D.17, E.03, E.06, E.09, E.15, E.17, E.19, E.21, E.26, E.28, F.07, F.13, F.16, F.19, F.21, F.23, F.31
15. Surface Mount Devices	A.5
16. Microprocessors and Interphases	G.01, G.03, G.04, G.05,G. 06, G.08
17. Microcomputers and Networks	H.01, H.02, H.03, H.04
18. Communications:	A.01, A.02, A.03, A.04, A.05, A.06
19. Laser Applications	C.01, C.02, C.03, C.04, C.05, C.06, C.07, C.08, C.09, E.22
20. Electromechanics	B.01, B.02, B.03, B.04, B.05, B.06, B.07, B.08
21. Hydraulics and Pneumatics	B.02
22. Advanced Troubleshooting	E.23, F.04, F.25, F.27, F.29, F.33, G.02, G.07, H.05
23. Programmable Logic Controllers (PLC)	Additional

The PR-ATE will address the identified needs by improving the teaching and learning process in participating institutions to meet the national standards in electronics education through three main strategies: incorporating technology-based curricular materials, preparing faculty in effective teaching practices, and developing work-related technical learning experiences for faculty and students. Other areas of need identified through the assessment which are related to basic science and mathematics content are to be addressed through the PR-SSI and PR-LSAMP reform, and areas related to general work skills, work ethic and behavior, interpersonal relations and team

work, such as "B.03- employ appropriate skills for gathering and retaining information", will be addressed through the School to Work Program. The **PR-ATE** proposes to achieve the following objectives:

1. To increase high level learning and strengthen mastery of knowledge and skills in key areas of electronics content among students through the development, pilot testing and adoption of standards-based WWW/CR-ROM interactive curricular modules and integration of effective teaching strategies into the electronics curriculum;
2. To enhance faculty preparation in the use of effective teaching strategies, integration of Web-based modules in the curriculum, and key areas of content in advanced electronics, through the development and implementation of a teacher and faculty enhancement program, to ensure that students can satisfactorily meet the national standards in electronics;
3. To offer technical experiences in the electronics industry for students and faculty to gain first hand knowledge and skills of key applications and specialized techniques through hands-on learning experiences, to reinforce mastery of national skill standards;
4. To strengthen collaborative ties among secondary schools, two- and four-year colleges, and industry to ensure a smooth transition among educational levels, and the continuous improvement of ATE in electronics, to support excellence and competitiveness of the national science and technology base.

The development of the PR-ATE project will directly benefit over 20,000 students and over 150 teachers and faculty members from secondary to undergraduate level programs in Puerto Rico over a three year period, while also reaching students and faculty in the U.S. mainland by promoting the dissemination of the Project's products and developments.

V. Project Plan

A three-pronged interinstitutional strategy has been established to strengthen academic offerings through the PR-ATE project during 2001-2004: 1) Curricular Enhancement through the integration of interactive WWW/CD-ROM based modules; 2) Faculty and Teacher Enhancement Workshops and Seminars and follow-up to ensure impact on teaching practices; and 3) Integration of Technical Experiences that link learning between the classroom and industry. A timetable for the development of each of the project components is presented on pages 29-30.

Component I: Curricular Enhancement through WWW/CD-ROM interactive modules:

Ten (10) curricular modules in WWW/CD-ROM format will be developed to address content topics and skills areas identified in the institutional assessment. These modules will be highly interactive, focusing on conceptual development and depth-of understanding, and will incorporate assessment of learning progress. Each module will be designed to allow users to advance through learning levels, from high school to a baccalaureate degree. When appropriate, adaptations from national exemplary curricular materials will be made and links to resources available through the Internet will also be incorporated. Some examples of applicable exemplary projects funded by the NSF-ATE program which are developing computer based modules and which will be sought as collaborators in the PR-ATE are:

1. Miami University, Middletown – Increasing the ImPACT (Award #9950011);
2. Moraine Valley Community College – Applied Internet Technology: Curriculum and Careers (Award #9950037);
3. Rock Valley College – Development and Field Test of a Multimedia Simulation System for Training Aviation Technicians via the Internet (Award #9950088).

In addition to these projects, experts from several ATE national centers of excellence, particularly those at Arizona, Ohio, and New Jersey, because of the focus of their central themes

(manufacturing and telecommunications) will be consulted to identify exemplary materials and resources to assist the PR-ATE staff in the development of the modules as well as other project components.

The main focus of these modules will be the development of interactive activities that require promote learning of content matter and skills through problem analysis and solving using work-related situations that will prepare students better for the workforce. One of the main difficulties in teaching electronics is the level of abstraction involved. It is hard to explain concepts and principles if students are not able to observe such concepts of principle in a real life situation. To overcome this difficulty, the following general format will be used for the development of the modules:

Section	Description	Objectives
Motivating module –	Through video and audio clips,	Without even knowing the
Problem set up	or computer simulation of	Underlying principle,
	Circuits or devices, the	mathematical formulation or
	Response of a particular circuit	concept, students discover
	or device to a specific	by themselves an actual circuit or
	Voltage or current source	device response thus
	is presented.	increasing motivation levels.
Didactic – Problem	The underlying concept	Once students have seen how
explanation	Explaining the observed	the circuit or device works, they
	Response is presented.	will be more receptive to the
		physics or formulation that
		explains the observed response.
Didactic – Example	Another example correlating	An additional example will
	the physical phenomena with	help the student integrate
	the underlying concept is	the learned concepts.
	Presented.	
Assessment	Questions or exercises will	It is essential to assess student
	Assess student learning.	learning before more advanced
	If the assessment indicates	material is presented.
	Deficiencies, the previous step	

	with a different example	
	will be repeated. If assessment	
	Outcomes are satisfactory, a	
	new motivating module (first	
	step) presenting a more	
	advanced concept to the student.	

Each will be developed by a team of professors from the three campuses who specialize in the pertinent content areas module, led by one of the Project's Co-PIs. The teams will be assisted by an instructional technology consultant. Modules will be developed in consultation with industry experts and an external advisor from one of the highlighted NSF-ATE exemplary projects or centers. The modules produced will be initially validated by panels of faculty, industry representatives and students from all participating institutions. The instructional technology consultant will design the modules for WebCT format and a webmaster will program the modules and upload them to the PR-ATE Website. Since the modules will be developed in both Spanish and English, a language editor will assist the groups in their translation/editing. The modules will be made available to all students nationwide through the WWW and complemented with CD-ROMs.

Each module will be articulated with the corresponding courses to ensure that they enrich the curriculum. The modules will be included in the course syllabi and will be used as an integral part of the course material. Students will be able to use the modules at their own pace, outside of the classroom, since they will be made accessible to students and faculty of all participating institutions through the WWW site to be operated through a server at the UPR-Aguadilla as well as through CD-ROMs. Faculty will be supported in their effective use and integration in the courses as part of the faculty enhancement component (see next component).

WebCT will be used as the platform for the development of the modules. WebCT is a tool that facilitates the creation of sophisticated WWW-based educational environments. It does this in three ways: it provides an interface allowing the design of the presentation of the course (color

schemes, layout, etc.); it provides a set of educational tools to facilitate learning, communication and collaboration; and it provides a set of administrative tools to assist the instructor in the process of management and continuous improvement of the course. Additional tools such as Authorware and Photoshop will be used to design and produce the modules.

The development of the curricular modules will focus on the basic content areas corresponding to themes # 1-13 presented in the institutional assessment table (page 12) and will be developed and tested in two cycles. During year one, the first set of five modules will be developed, pilot tested during year two and fully disseminated in year three. A second set of five modules related will be developed in year two and pilot-tested and disseminated in year three. Additional modules related to more advanced content areas (# 14-22 from the table on page 12-13) will be developed at a later time, using the experience and feedback obtained from the first set of modules. Assessment methods, such as pre and post-tests, will be included in the modules, to provide the students with immediate feedback on their progress, and to evaluate the overall effectiveness of the modules on student performance.

Component II: Teacher and Faculty Development for Enhancing the Teaching and Learning Process

To assist teachers and faculty at participating institutions in their efforts to incorporate curricular enhancements to meet the national standards and strengthen student learning, a series of professional development activities will be offered focusing on three areas: a) the incorporation of best teaching practices in electronics education, following an inquiry-based teaching approach; b) the incorporation of WWW/CD-ROM curricular modules developed through the PR-ATE to ensure the full and effective integration of these modules throughout the curriculum, as well as to stimulate faculty to incorporate other exemplary modules in their courses; and c) advanced topics in

electronics education to ensure that faculty are abreast of the cutting-edge advances in the field in key areas identified in the national electronics skills standards and relevant to local high-tech industries. Professional development activities will be open to participants from all PR-ATE institutions and will be offered on a rotational basis at the different institutions, including at partner industry sites when appropriate to the particular topic. Participants from secondary schools will be granted continuing education credits, which teachers require to fulfill the Teacher Career Ladder of the PR Department of Education.

a) Incorporating best teaching practices into Electronics Education*:* Following the findings of educational research and the successful experience of the PR-LSAMP, the PR-ATE will promote the integration of effective teaching practices that emphasize inquiry and conceptual understanding throughout the Electronics Education programs. To ensure that all faculty members are adequately prepared in this teaching approach and are well equipped to redesign courses within this framework, specialists from the PR-SSI and PR-LSAMP curricular development and professional enhancement components will serve as advisors and resources for **PR-ATE** faculty. A seminar in teaching for inquiry based and conceptual understanding will be offered consisting of five sessions per year during years one and two, in which teachers and faculty will learn about relevant educational theory and research findings, and effective teaching and assessment strategies, and will be assisted in the application of these strategies into the field of electronics and in redesigning the courses they teach. . The UPR-telecommunications facilities of the Virtual Classrooms will be used to facilitate participation from all PR-ATE institutions and others from abroad. Follow -up with seminar particpants will be carried out by the PI and CoPIs during the year through periodic on-site meetings and electronic discussions in which participants will be encouraged to share their experiences and present the results of their implementation efforts.

b) Incorporation of PR-ATE web-based modules into electronics courses: To ensure that all teachers and faculty in the PR-ATE partner institutions are effective in the use of the Web-based modules developed through the PR-ATE, and that the modules are fully incorporated into their classes, a half-day workshop will be offered on each modules at the three PR-ATE postsecondary institutions once these have been developed (second and third project years). The workshops will stress demonstrations of the modules and hands- on experiences with the modules for teachers and faculty . During the workshops, participants will be assisted in incorporating the modules as key curricular material into their courses. To promote the actual incorporation of the modules in the courses, the PR-ATE staff will provide follow-up support through on-site visits and meetings at each institution to identify implementation needs and issues to be addressed to assist faculty in making optimal use of the modules in their courses.

c) Advanced Topics in Electronics in Manufacturing, Communications and Information Technologies: To prepare faculty to strengthen curricular offerings by incorporating advanced content in electronics manufacturing, communications, and information technologies, particularly related to recent developments in each field, seminars on Advancements in Electronics Education will be offered. The topics to be addressed through this seminar series will include those identified in the needs assessment conducted by the planning group, particularly those themes corresponding to numbers 13-23 in the national standards skills table (proposal pages 12-13). A total of seven seminars averaging 20 hours per seminar will be offered in years 2 and 3. Specialists in each of the content areas will be recruited to offer the seminars, including experts from industry. Sessions will provide activities to encourage and assist faculty in designing innovative curricular activities to incorporate the seminar content into their courses. Follow-up to participation in these seminars will be carried out by PR-ATE staff to determine the extent to which the participants in the seminars are

using what they learned to enhance the curriculum. Seminars will include visits to industry to learn applications of the main concepts through their applications in the work context. These visits will be coordinated with the technical experience component (see next component).

Component III: Incorporating Technical Experiences to link learning in classroom and industry:

Most of the academic programs of the institutions participating in the PR-ATE provide minimal technical experiences for students and faculty, mostly the short term experiences provided through STWP which emphasize career exploration and the development of broad employability skills. Through the PR-ATE, opportunities for extended technical experiences that emphasize in-depth learning of the key concepts identified in the institutional needs assessment according to the national standards will be provided. The new technical learning experiences will be focus on problem-solving situations that link learning in the classroom with real work problems encountered in industry settings so that students and faculty can gain first-hand experience in the development of knowledge and skills that are needed to ensure the optimal employability of graduates in the industrial sector. These experiences will draw upon the successful Academic/Research Modules on Industrial Products developed through the STWP, which include the following process:

- Teachers visit the industry to learn first hand about workplace concepts and technologies;
- Industry representatives visit the school to present their products to students and teachers to familiarize them with their operations;
- Students research the product manufacturing process and other resources needed to produce the product. They work in teams under the close supervision of a multidisciplinary team of teachers;
- Industry representatives conduct a second visit to the school to present the product manufacturing process;
- Students have the opportunity to revise their projects according to what they learned from the second presentation;
- Students visit the industry to observe how the product is actually made and the different types of personnel involved in producing the product.
- In a closing activity, students present their work to peers, teachers, and employers.

Some of the focal areas in which the PR-ATE staff will develop technical experiences will include troubleshooting, communications and information systems, pneumatics, digital circuits, microprocessors, visual basic, and PLC. The following are examples of possible technical experiences to be provided in each of the major fields:

Possible Experience in an Electronics Manufacturing Industry

- A participating industry in the electronics manufacturing sector identifies a program mentor.
- Program administrators contact the program mentor at the participating industry and arrange for a visit by teachers and students.
- Teachers and students observe how production line rejected products are processed by the repair section. They also interview the key industry workers in charge of the repair process. Teachers and students collect as much information as possible.
- Students working as a group identify opportunities for reducing repair time. Alternatives to be studied include: recommend automatic test systems, recommend the development of virtual test instrumentation, improved diagrams for the repair technician to follow, recommend alternate test equipment, improved test sequencing to be followed by the repair technicians, recommend additional tests to be conducted, recommend the elimination of inefficient or redundant tests.
- Students and faculty visit for the second time the participating industry and present to the mentor and other key industry personnel their recommendations.

Possible Experience in a Telecommunications Service Provider

- A participating provider of PCS/cellular service identifies a program mentor.
- Program administrators contact the program mentor at the participating service provider industry and arrange for a visit by teachers and students.
- Students and faculty will be able to observe either an acceptance test of a new cell site to be placed in service or a scheduled maintenance service at either a switching or transmission facility.
- Students will observe the instrumentation used, the test sequencing being followed, the type of tests performed, and the overall procedure. Students will record as much detail of the conducted tests.
- Students working as a group will search the literature and the Web to identify opportunities for improving the test procedure. Alternatives to be studied include: recommend automatic test systems, recommend the development of virtual test instrumentation, improved diagrams for the repair technician to follow, recommend alternate test equipment, recommend improved test sequencing to be followed by the repair technicians, recommend improved procedures, recommend additional tests to be conducted.
- Students and faculty visit for the second time the participating service provider and present to the mentor and other key industry personnel their recommendations.

During project year 1, a team of faculty will design the technical experiences, following visits

to industry sites and interviews with industry representatives, and will ensure a minimum of five student placements per institution for project years 2, to be increased to 10 placements per institution for year 3. Representatives from industry will serve as mentors following the successful Employer Participation Model developed by the STWP, and will capitalize on the fact that many have already been trained in effective mentoring techniques. At the beginning of the school year, an orientation session will be offered to advanced students enrolled in electronics programs at the postsecondary PR-ATE institution, highlighting the diverse industrial sites available. The technical experiences will be presented as an optional part of a course. Students will spend up to 80 hours during one year in these experiences and will have the option of investing the total number of hours in one or more sites, depending on their learning needs and interests and the availability of the sites.

The development of project teams of students working together at the industry sites will be encouraged to promote team project-based experiences. Faculty will assist students in elaborating their technical experience plans, and will make the final arrangements with the industry representative to receive and work with each student. Students will submit weekly reports to faculty and their industry mentor on their activities with emphasis on what they have learned in connection with concepts learned in different courses and according to assessment criteria based on the key standard-based skills. An electronic bulletin board will be created for participants, faculty and industry mentors to communicate concerning issues that arise from the experiences to improve the learning process. Participants will be required to prepare a portfolio of their experience to be presented at the end of the year. Each student will be paid a stipend of $6.15 per hour for their participation in the technical experiences. A team of faculty and industrial mentors will delineate a plan to expand the technical experiences and incorporate these as an integral part of the curriculum.

VI. Experience and Role of Senior Personnel:

The PI for this Project will be Helen Sosa, Ph.D. who has been the Project Director of the School to Work Program in High Technology at the RCSE during the past four years. Dr. Sosa has a broad academic and professional background in education, having been involved as director and consultant in several major projects related to the educational reform in Puerto Rico. As Project Director of the SWTP, she has exerted strong leadership and managerial capabilities required for the success of a large scale systemic reform project in technological education that calls for close collaboration among multiple institutions and partners. As full-time Principal Investigator of the PR-ATE at the Resource Center for Science & Engineering, Dr. Sosa will be responsible for the overall implementation and day-to-day management of the project, ensuring the optimal coordination of efforts among the diverse institutions by building an effective project workteam for the planning, design, implementation and evaluation of the project activities following the Project Timetable (see pages 29-30). She will provide ongoing support to each institution in the implementation of the project, and will monitor the effectiveness of all efforts. Dr. Sosa will work closely with, and be accountable directly to Dr. Ana Piñero, Associate Director of the RCSE, and Co-PI of the PR-LSAMP, who will oversee the Project's development to ensure its effective articulation with other RCSE systemic initiatives (PR-SSI and PR-LSAMP). As a unit of the Central Administration of the UPR system, the RCSE is under the Presidency of the UPR, a position which facilitates the multi-institutional collaboration among campuses and provides access to the high level academic administrative leadership to ensure institutional support and decision-making to advance the project's successful implementation and sustainability.

Part time Co-Principal Investigators will be designated at each of the participating postsecondary institutions, who will be faculty from the Departments of Electronics. Professor Anibal Romney from UPR at Aguadilla , has an MSEE from the Mayaguez Campus UPR, with

specialized background in control systems and power electronics, and switching power supplies, and has special interest in computer programming. Professor Daniel Chéverez, from the UPR at Bayamón has an MSEE from the Mayaguez Campus-UPR specializing in control systems and power electronics applied to photovolcaic energy. His teaching interests include PLC, Pneumatics, Sensors and Electrical motors. Professor Chéverez has worked with the STWP Curricular Revision Committee and has been a professional development resource in the constructivist approach to teaching. Dr. Ricardo Mediavilla, Director of the Electronics Department at UPR at Bayamón will serve as Co-Principal Investigator of the project providing expertise in the area of Communications and Information Systems. Professor Mediavilla has a Ph.D. in Electrical Engineering from Rensselaer Polytechnic University. He has been a researcher at Bell Labs and his experience spans academia, engineering design work, research, development and manufacturing. Professor Dr. Juan C. Cersósimo will be Co-PI for the UPR at Humacao. Professor Cersósimo obtained a Ph.D. in Astronomy from the Universidad Nacional La Plata, Argentina. His special area of interest is electronic communications (satellite transmission). Each CoPI will be granted three credits of release time and will work an additional three credits, for a total of six credit hours throughout the academic year, and three credits during summer. The main function of the CoPIs is to ensure the full participation of the institution they represent in the project, coordinating the implementation of the project activities in collaboration with the team of PI and CoPIs. Each CoPI has been designated by the Chancellor of their institutions, and will be provided full institutional support for their participation in the project (see letters of endorsement from the Chancellors of the three postsecondary units). The CoPIs will be in charge of promoting and facilitating the participation of their faculty and of the teachers of neighboring secondary schools who are partners in all PR-ATE activities. They will also be team leaders in the development of the interactive WWW/CD-ROM

curricular modules, as each of the CoPIs will be the leader of at least one of the five modules to be developed in years one and two. They will also be responsible for the coordination of the faculty and teacher enhancement activities to be offered at their respective institutions, and of coordinating the design and implementation of the technical experiences to be made available to the students at their institutions. An Advisory Board will be established comprising representatives from all PR-ATE partner institutions and sectors including Chancellors, faculty, students, industry and external advisors from relevant NSF ATE Centers of Excellence. They will meet twice a year with the PI and CoPIs to review and provide recommendations on the PR-ATEs progress, evaluation reports, and workplans.

VII. Project Evaluation:

The formative and summative evaluation component will be carried out by the PI and CoPIs, assisted by an educational evaluation consultant, through ongoing communication via e-mail and telephone and semi-monthly project meetings to discuss progress, identify obstacles and devise solutions to ensure the optimal effectiveness and efficiency of the project implementation according to the established workplan. The evaluator will collect data documenting the implementation of all activities on an institutional and projectwide basis and will provide results and findings as feedback to project staff to support decision-making in staff meetings. A participant data base will be created and updated to evidence the quantitative impact of the project. The production of curricular modules will be monitored to determine the degree to which interactive experiences are incorporated to enhance learning according to national standards. The quality of the content and instructional design of each module will be evidenced through an external evaluation by experts in the field and the effective use of the modules in the courses will be assessed through course syllabi and user data. Each faculty and teacher enhancement activity offered by the PR-ATE will be evaluated by

participants as to the extent to which the activities contribute to enhance their teaching practices. Follow-up activities with faculty participants in enhancement activities will evidence, through surveys, interviews and focus groups, the impact of the activities and the extent to which participants are integrating innovations into their courses and teaching practices, and the assessment of these innovations in terms of student learning. Technical experiences will be evaluated by interviewing students and industry mentors to obtain their insights and assessment of student learning and performance as well as to improve the design of the activities.

The summative component of the project evaluation will focus on producing evidence of the degree of achievement of project goals and objectives through increased alignment with the national standards in the curriculum, faculty enhancement, and technical experiences. The external evaluator will assist the Project Staff in the development of quantitative and qualitative criteria for each objective and benchmarks for student performance based on the national standards for the key skills and content which were identified as target areas for improvement. Based on these criteria and benchmarks, a battery of instruments, including pre-post tests, will be designed and administered to samples of the participating cohorts of faculty and students. To assess improved preparation of students entering the workforce, a sample of graduates will be tracked to determine employment, and industry employer satisfaction will be measured. The experience of the PR-SSI and PR-LSAMP Program Assessment Components in the development of measurement criteria and diverse authentic assessment methods and instruments will be used to develop the PR-ATE's summative evaluation design. An annual report will be prepared to present projectwide achievements and profiling the participation of each of the PR-ATE partners. The final three year report will synthesize the major changes achieved in electronics education and present recommendations and mechanisms for the further advancement and dissemination of these efforts. A timetable for the Evaluation Component

is included in the Project Timetable on pages 29-30.

VIII. Project Dissemination:

The RCSE will promote broad exposure of the PR-ATE project, at the statewide as well as national level, as part of is ongoing efforts to disseminate the systemic initiatives programs it is developing which are considered to be national exemplars of excellence in education. The ongoing collaboration between the PR-SSI with the New York City school system through the **PR/NYC Education Linkages Project** funded by the USDE will facilitate the dissemination of the PR-ATE products to this population. The PR-ATE Program will be disseminated throughout the secondary and postsecondary educational systems on the Island and the mainland. Through collaboration with several **NSF ATE Centers of Excellence,** mostly those at Ohio, Arizona, and New Jersey, the PR-ATE staff will identify specific sites that may benefit from the products and activities developed by the PR-ATE, to coordinate the exchange of information and services. The **WWW /CD-ROM curricular modules** to be developed will be made available to other institutions on the Island and the mainland. An exhaustive mailing list with the postal and e-mail addresses of institutions offering electronics education will be prepared and a brochure (hard copy and electronic) describing the modules and a CD-ROM with a demo will be sent to each one. The modules will also be provided to the NSF ATE Centers of Excellence that have a clearinghouse to consider including them. Open access to these modules will be provided, along with technical assistance to ensure their proper use.

The best practices resulting from teacher and faculty enhancement activities will be publicized through the WWW, as well as through presentations at various local and national forums. Several local and national forums and journals related to electronics education and the electronics industry will be targeted for dissemination activities, such as those of the **IEEE Frontiers in Education Conference, the Association for Career and Technical Education, the Association of**

American Community Colleges, and the Electronics Industries Foundation. Finally, a one-day, islandwide **Showcase of Advances in Technological Education** will be held to offer presentations and workshops of the PR-ATE accomplishments and products by participants to a broad audience from the technological education community, from the electronics, communications, and information systems industries and from economic development government agencies.

COMPONENTS/ACTIVITIES	YEAR 1				YEAR 2				YEAR 3			
	1ST QTR	2ND QTR	3RD QTR	4TH QTR	1ST QTR	2ND QTR	3RD QTR	4TH QTR	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Component I: Curricular Enhancement through WWW/CD-ROM Modules												
1. Establish teams for the development of five modules, integrating CoPI, faculty and teachers from participating institutions.	✓				✓							
2. Teams design modules with assistance from instructional/technology consultant, in staggered schedule based on two months per module, including consultation with industry experts in pertinent fields, and editing of modules. Instructional/technology consultant programs modules for WebCT and uploads to WWW in server at UPR- Aguadilla.		✓	✓	✓		✓	✓	✓				
3. Teams pilot-test modules in courses, analyze results, and fine-tune modules. A one-day workshop will be held for each module with students, faculty, and industry representatives to validate the modules.			✓	✓	✓		✓	✓	✓			
4. Instructional/technology consultant completes uploading of completed modules in WebCT for full implementation in PR-ATE institutions and broad dissemination.					✓				✓			
5. Modules are fully integrated into the appropriate courses (following faculty workshops on integration of modules into courses- see Component II, Activity 6). Gather and analyze results from student assessment to determine impact of modules on enhancement of student preparation according to national standards.						✓	✓	✓		✓	✓	✓
6. Broaden dissemination of curricular modules and results in improving student learning at local and national level.										✓	✓	✓
7. Faculty identify curricular areas for development/acquisition of additional modules according to national standards.											✓	✓

COMPONENTS/ACTIVITIES	YEAR 1				YEAR 2				YEAR 3			
	1ST QTR	2ND QTR	3RD QTR	4TH QTR	1ST QTR	2ND QTR	3RD QTR	4TH QTR	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Component II: Faculty and Teacher Enhancement												
1. Design five-day seminar for faculty and teachers on best practices in effective teaching strategies, in collaboration with PR-AMP and PR-SSI staff, with emphasis on inquiry for conceptual understanding.	✓											
2. Announce seminar among PR-ATE faculty and teachers and produce materials for faculty development.	✓											
3. Offer five-day seminar to faculty and teachers from PR-ATE institutions.		✓				✓						
4. Carry out follow-up with participants to assess incorporation of innovative teaching practices in courses, through site meetings, electronic discussions and bulletin boards where faculty will present experiences in the applications of strategies and results in student learning.			✓	✓			✓	✓				
5. Design workshops on advanced topics in electronics.				✓				✓				
6. Design and implement one-day workshops for faculty to learn to use and incorporate developed WWW/CD-ROM curricular modules into courses.					✓	✓			✓	✓		
7. Announce and offer one-day workshops on advanced topics in electronics education to PR-ATE faculty.						✓	✓	✓		✓	✓	✓
8. Carry out follow-up to participants in workshops on advanced topics in electronics to assess integration of topics into courses.							✓	✓			✓	✓
9. Celebrate Showcase of Innovations in Electronics Education for dissemination and faculty enhancement, in which faculty present results of implementation of innovations in curriculum as result of participation in seminars and workshops.										✓	✓	✓

COMPONENTS/ACTIVITIES	YEAR 1				YEAR 2				YEAR 3			
	1ST QTR	2ND QTR	3RD QTR	4TH QTR	1ST QTR	2ND QTR	3RD QTR	4TH QTR	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Component III: Integration of technical experiences to link learning in classroom and industry												
1. Establish teams to design technical experiences in industry.	✓											
2. Faculty visits industry to become familiarized with key aspects for design of technical experiences for students in collaboration with industry representatives.	✓											
3. Teams design technical experiences for students and make arrangements with industry to ensure student placement and assignment of mentors.		✓	✓	✓								
4. Assign students to technical experiences in industry with support of industry mentors (80 hour experience per student)						✓	✓	✓		✓	✓	✓
5. Faculty follow-up on students in technical experiences and offer classroom activities to explore linkages between curricular concepts and experiences in the field.						✓	✓	✓		✓	✓	✓
6. Faculty revise technical experience design for next year implementation and scaling up. Ensure additional placements for next year participants.								✓				
7. Faculty revise technical experiences based on assessment, and seek institutional mechanisms to sustain technical experiences as part of the curriculum.											✓	✓
8. Develop presentations on technical experiences for dissemination in Showcase on Innovations in Electronics Education (Component II, Activity 9).										✓	✓	