Curricular Revision Focused on Student Learning at Minority Institutions: the Case of the Puerto Rico - Louis Stokes Alliance for Minority Participation[1]

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Abstract

Lead by the University of Puerto Rico Resource Center for Science and Engineering, several higher education institutions on the Island have been collaborating for various years in the Puerto Rico LSAMP (PR-LSAMP) program. The core PR-LSAMP is the curricular revision of Science, Mathematics, Engineering and Technology (SMET) courses to improve student performance. This paper describes the curriculum assessment, innovation strategies and outcomes of the PR-LSAMP program during a period of seven years. The curricular initiatives of the program include identification, assessment and reform of SMET "gatekeeper and bottleneck" courses; description of successful reforms institutionalized at several institutions (such as integration of laboratory & courses, use of active/cooperative learning, and faculty development). The current multi-faceted curricular innovation strategy is presented.

I. Introduction

The Louis Stokes Alliances for Minority Participation (LSAMP) program is a multi-disciplinary, comprehensive, undergraduate program sponsored by the National Science Foundation to increase substantially the quantity and quality of participating students receiving baccalaureate degrees in science, mathematics, engineering and technology (SMET). LSAMP facilitates achievement of the long-term goal of increasing the number of students who earn doctorates in SMET fields, especially those who choose to take faculty positions on colleges and universities.

The LSAMP project supports undergraduate education systemic reform in alliances that include partners from two- and four-year higher education institutions, businesses and industries, national research laboratories, local, state, and federal agencies. In addition to this principal focus, LSAMP projects also give consideration to the critical transition points in SMET education: high school to college; 2-year and 4-year college; undergraduate study; and graduate-to-faculty career.

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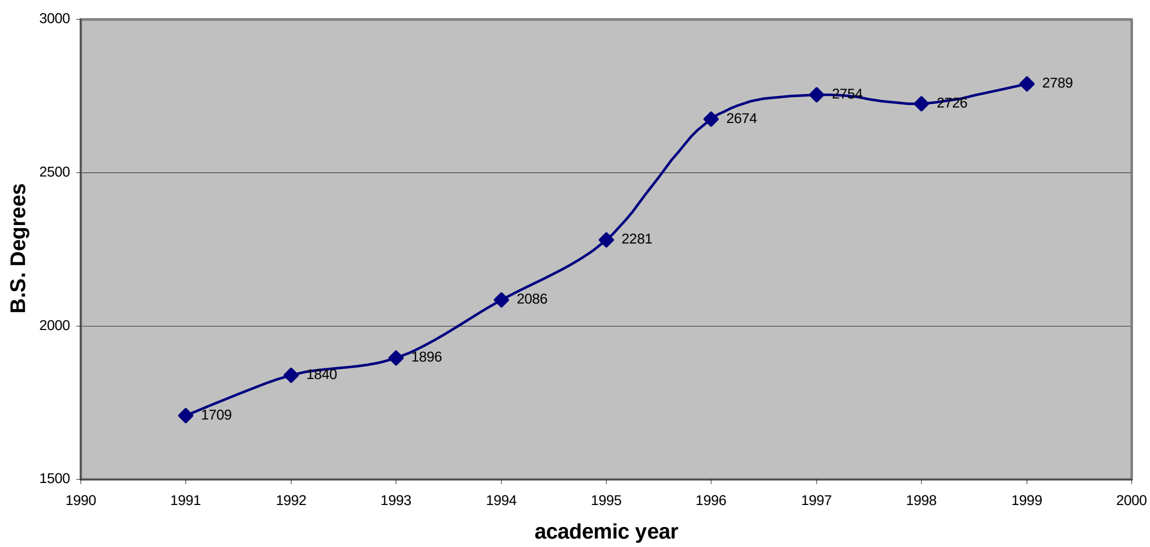
Since 1991 several higher education institutions in Puerto Rico, lead by the University of Puerto Rico Resource Center for Science and Engineering, have been collaborating successfully in the Puerto Rico LSAMP program (PR-LSAMP; website: http://shuttle.uprm.edu/pramp). These institutions enroll 80% of all undergraduate SMET students in Puerto Rico. Two-thirds (2/3) of these students are the first generation in their families to attend college, and around seventy percent (70%) come from low-income households. In a period of seven years the PR-LSAMP institutions achieved a 60% increase in the number of SMET baccalaureate degrees awarded as shown in Figure 1. For a cohort of students entering SMET programs in 1991-92, the average SMET graduation rate within the (public) UPR system is 62%, and for private institutions is 49%, averaging 58% for the Alliance (seven institutions).

Figure 1. PR AMP Degree Production Curve



Two of the most critical and successful components of this program, which have led to the improvement of the effectiveness and efficiency of SMET undergraduate programs, are **curricular revision and innovation, and, the use of active teaching/learning strategies**. Due to institutional diversity among the members of the Alliance, each institution is responsible for these activities. Nevertheless, two Centers island-wide promote and provide leadership and direction towards a common goal. They are the ***PR-LSAMP Curriculum Innovation Center*** and the ***UPRM Center for Professional Enhancement, co-sponsored by PR-LSAMP***. The Curriculum Innovation Center facilitates the assessment, development and innovation of SMET curricula and the Center for Professional Enhancement provides opportunities for faculty development in the areas of teaching, learning, assessment and classroom research through seminars and workshops year round.

II. Phase I: The First Five Years

Some of the outcomes of Phase I (first five years) of the PR-LSAMP Island-wide include:

- Enrollment in SMET programs has almost doubled from baseline year 1991. Enrollment in 1991 was 12, 572, increasing to 24, 997 in 1998.
- Graduation rates increased from an average of 32% to an average of 60% system-wide
- Reduction in the number of times a student repeats a course.
- 40% of the Hispanics that obtained a doctorate degree between 1991-95 from one of the top 25 institutions (ranked according to total SME doctorates), received their BS degree from an AMP institution.
- Assessment and revision of SMET "gatekeeper"& "bottleneck" courses.
- Curriculum materials developed.
- Use of active/cooperative learning strategy in SMET courses.
- Study/learning skills within the context of a course workshop (TaDDEI).
- Use of performance indicators and metrics to assess outcomes.
- Faculty development in teaching/learning strategies.
- Articulation with other NSF systemic programs (PR-SSI and EPSCoR).

III. Curriculum Revision During Phase I.

During the first five years of the PR-LSAMP project, curriculum revision was carried out by the Center for Curriculum Assessment and Revision. An inter-institutional and interdisciplinary committee, providing guidance and support, and, disseminating strategies, aided this Center, directed by Dr. Josefina Arce from UPR-Río Piedras Campus and respected Chemistry professor. As part of the initial activities PR-LS AMP institutions carried out curricular assessments of four undergraduate entry-level courses – General Chemistry, General Biology, General Physics and General Mathematics -- that tend to discourage students from continuing studies in science, math, engineering and technology-related disciplines. Assessment participants were University of Puerto Rico at Rio Piedras (UPR-RP), University of Puerto Rico at Mayagüez (UPR-M), University of Puerto Rico at Humacao (UPR-H), Interamerican University (IAU), Metropolitan University of the Ana G. Méndez University System (UMET). Faculty from these institutions were especially concerned about high attrition, including failures and withdrawals, in this entry level course, and about students' feelings of discontent with the course. Surveys were administered to current and former students (including UPR-RP and UPR-RUM students who had dropped the course), professors, and professors from other disciplines that use concepts taught in the courses. Information gathered included student perceptions of and attitudes towards the course, teaching methodologies used by faculty, topics considered by different populations to be superfluous or essential, usefulness of the course as a preparation for advanced courses, and main difficulties experienced by students and teachers.

Specific recommendations concerning these courses were made to SMET departments. In general, in order to increase the number of students succeeding in these courses, assessors suggested:

- Changes in curriculum - Unload, slow down and go deeper in selected areas.
- Changes in teaching methodologies - Provide for different ways of teaching/learning.

- Changes in students - In attitudes and disposition towards learning, give them the tools they need to better equip them to face their academic needs.

IV. Phase II: Curriculum Revision Strategies - The Curriculum Innovation Center (CIC)

Beginning in 1997 (Phase II), the strategies to carry on curriculum assessment and innovation shifted its focus. First, the name, mission and vision changed, placing emphasis on disseminating successful activities and strategies conducted in Phase I and involving more SMET faculty in curricular revision and innovation. The Center is lead by a Director and assisted by an inter-institutional, interdisciplinary committee. Major tasks of the CIC are curriculum revision and innovation, and, faculty development and learning strategies. The goals of the Center are:

- Improve effectiveness and efficiency of SMET undergraduate programs
- Revise SMET curricula and courses with special attention to "gatekeeper" and "bottleneck" courses (those with high attrition rates)
- Improve students' academic performance
- Develop and educate SMET faculty in teaching/learning methods
- Disseminate results and successful outcomes

Curriculum Innovation Center

Some of the outcomes of the past two years are described henceforth.

A. Inventory of successful innovations of Phase I.

The description and outcomes of Phase I curricular revision activities is currently being documented and will be published during the second semester of 1999-2000. In addition, it will be posted in the PR-LSAMP Virtual Institute's website: http://amp.bc.inter.edu/

B. Industry Collaboration: Skills for the Millennium**.**

One of the most significant accomplishments has been the compilation of skills, competencies and values required by employers of SMET graduates. The CIC met with a diverse sample of industry representatives, carried on brainstorming sessions and workshops with industry to gather their opinions of these skills. The list compiled was complemented by a literature search, which included the new engineering accreditation criteria, ABET 2000. A publication titled: ***Skills for the Millennium: the Graduating SMET Student Profile*** will be published and disseminated next semester. This compendium will assist SMET faculty in designing, revising and innovating courses that respond to employers' needs.

C. Faculty Development

Without faculty exposure and development in teaching/learning strategies and innovative activities it is virtually impossible to make changes in the academic culture. The CIC assisted by the UPRM Center for Professional Enhancement and other initiatives, conducts numerous workshops and seminars throughout the year. Some examples this past year have been:

- Teaching and Learning with Style, by Theresa Hein from American University and Dan Budny from Purdue University (see photo)
- The Learning Factory: Implementing ABET 2000, by a UPRM, Penn State and University of Washington faculty team (website: http://ece.uprm.edu/lfw)[2]
- Cooperative Learning, by César Malavé from Texas A&M
- Outcomes Assessment, by Gloria M. Rogers from Rose-Hulman Institute of Technology

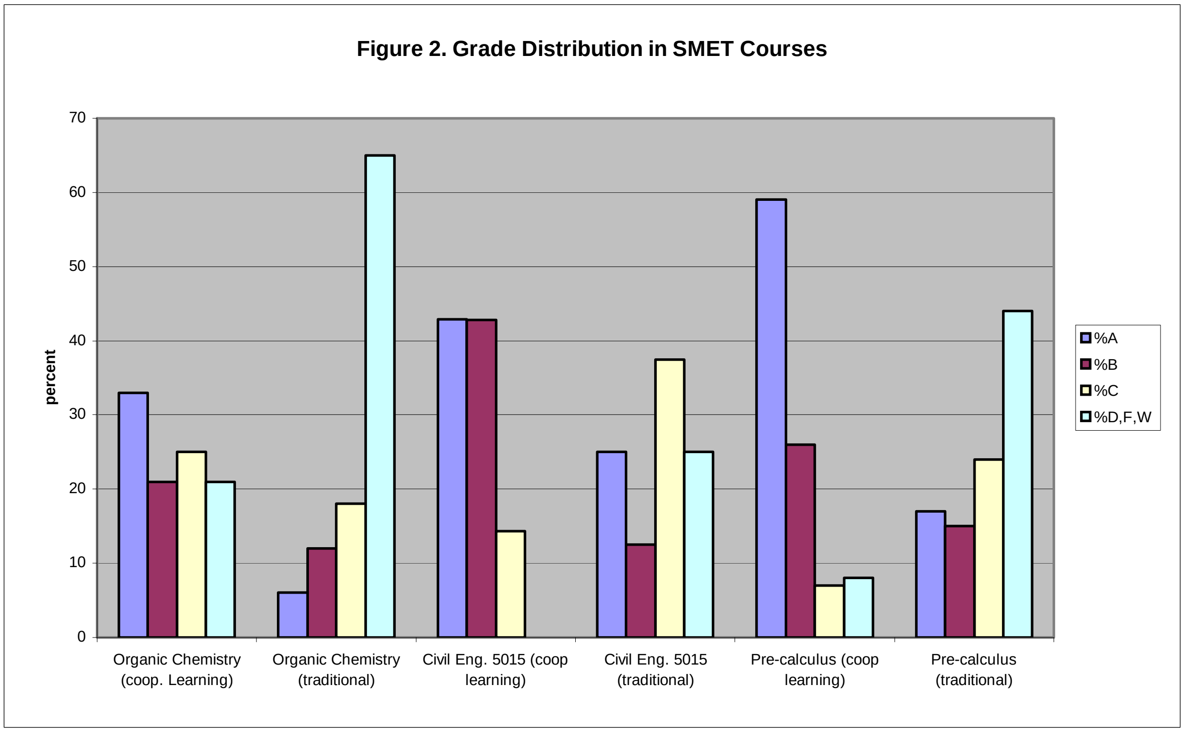
D. Request for Proposals for Curricular Innovations.

With the goal of motivating SMET faculty to engage in course and curricular innovation, in academic year 1999-2000 a request for proposal (RFP) was put out by the Center (see Addendum). The purpose of these $1,000 grants was to innovate SMET courses in PR-LSAMP institutions. Currently, fourteen (14) faculty from six (6) Alliance institutions are innovating their courses. Special emphasis was given to proposals involving "gatekeeper" and "bottleneck" courses and to the implementation of new teaching/learning strategies. An important requirement of the grant is outcomes assessment. Faculty receiving grants were required to attend a 6-hour workshop on Classroom Research and Assessment and are required to submit pre and post assessment of student performance and attitude changes as a result of innovation. They are also required to write a short paper in order to disseminate their experiences. These will be also posted on the PR-LSAMP website.

V. Specific Examples & Outcomes of Curricular Innovations

A. Cooperative Learning.

One of the most successful strategies to reduce the attrition rate in SMET courses across the Alliance has been cooperative learning[5,6]. Many faculty have participated over the years in workshops and seminars, and success stories in reducing student attrition rates have been documented. For example, Figure 2 shows a comparison of improvement in the grade distribution of various SMET "gatekeeper" or "bottleneck" courses (those with high attrition rates) with the use active learning approach. A compendium of strategies was put together by several SMET faculty in 1995 which includes successful strategies used in various SMET courses.[4]

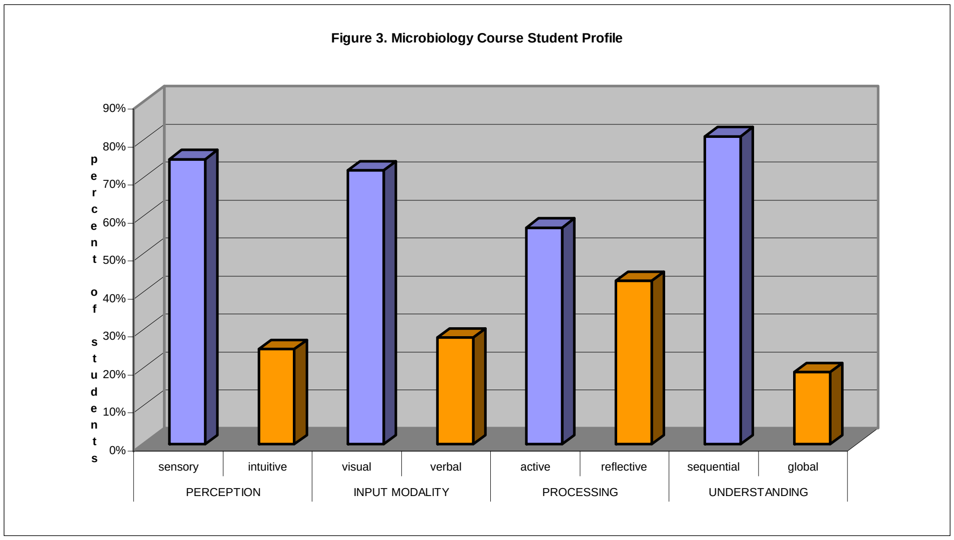


A 1998 survey to evaluate the impact that the cooperative learning strategy has had in SMET faculty across the Alliance suggests that many faculty are using to some degree cooperative learning as part of their teaching methodology.[3] Although incorporating cooperative learning in the classroom cannot be directly correlated to the increase in the number of baccalaureate degrees, it certainly shows a shift in the educational paradigm where faculty has become more receptive to an active teaching/learning strategy. Both new and experienced faculty seems to be using the strategy at all levels. Almost two-thirds of faculty members learned about the strategy by means of formal courses, workshops and seminars, and almost half of these were 10 hours of less in duration. More important, the study indicates that faculty uses cooperative learning frequently during lectures and the activities are primarily directed towards the: the learning new concepts, team projects and presentations, quizzes, and explorations of concepts. Over 60% of faculty felt confident in their knowledge of CL theory and role assignment, and somewhat less confident in other areas, such as conflict resolution, grading activities and individual accountability. In addition faculty perceive more positive than negative changes in student attitudes.

A specific example of the use of this strategy is the Organic Chemistry for non-majors offered by Dr. Rosa Betancourt of the UPR -Río Piedras Campus. This course is the case of a gatekeeper course where changes in curricular and teaching methods have reduced failure rates and improved students' morale. Since 1991, the trend is a reduction in the number of failures and withdrawals from the course. Since 1991, the percent of students successfully passing the course (earning A, B or C) have increased form about 50% to about 65%. Faculty teaching the course has gradually changed from a traditional content-driven, memorization-intensive lecture to a more decision-based, active learning methods. To promote this change, additional weekly one-hour sessions were added to the course programmed for demonstrations, quizzes and cooperative learning problem solving. Also, a Home Page was constructed that includes general course objectives, detailed operational objectives for every course topic, internet links to related sites, access to interactive modules, teamwork & cooperative learning modules and tips, quizzes, exams (including old exams) and any other course material.

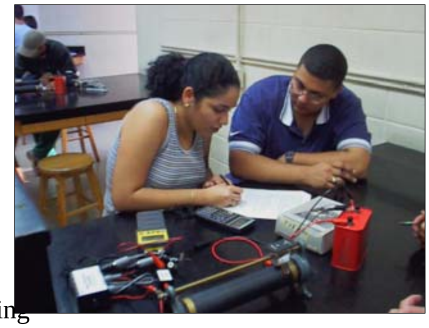
B. Use of Learning Styles to Design Classroom Activities.

In 1998, Buxeda[1] performed a learning style study using the Solomon and Felder Learning Style Model[2] with the purpose of enhancing student learning with focused classroom activities. One hundred eight (108) undergraduate students taking the general Microbioloy course were given the learning styles inventory. As shown in Figure 3, the study indicated a diversity of learning styles among the students.



Some of the classroom activities designed to address the various learning styles include: making a microbiology collage, newspaper interviews, making microbiology models, portfolio and projects. All classroom activities make use cooperative learning. Besides the change in teaching/learning methodology, this strategy also entailed a change in student performance assessment. Therefore, in addition to traditional exams and quizzes, students were requested to document learning experiences in a student portfolio.

C. Integration of Class & Laboratory



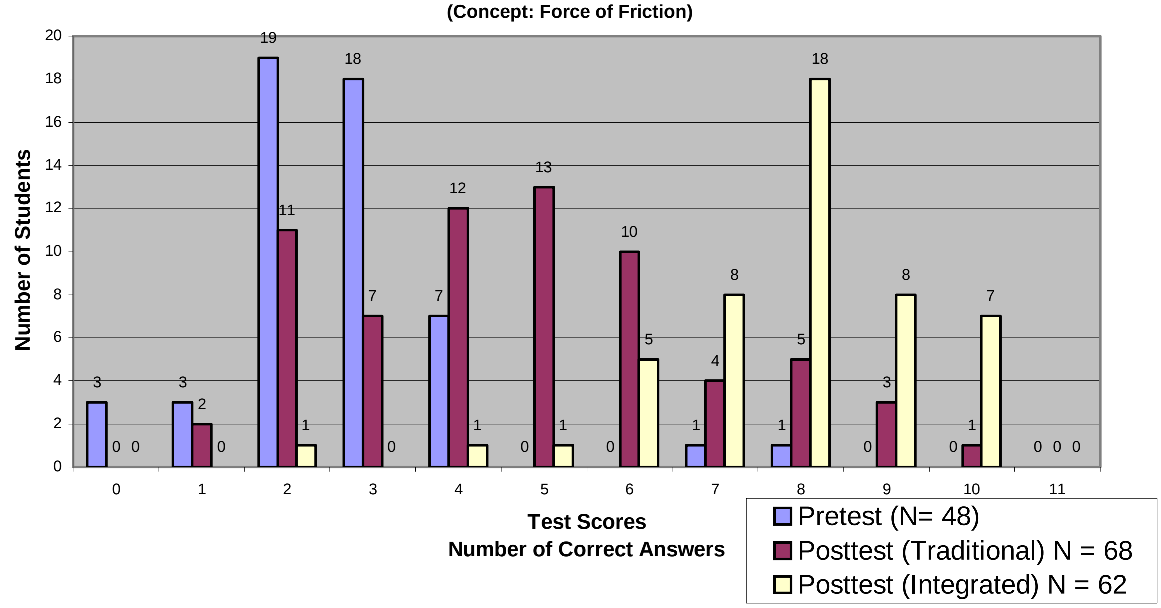
Dr. José R. López chose to integrate the Physics for Engineers course lecture and laboratory sessions using a constructivist approach to promote active learning. The goal was to put the student at the center of the teaching-learning process[7]. Originally, the traditional course consisted of four one-hour lecture sessions and a separate two-hour laboratory, for a total of six contact hours each

[2] Index of learning styles available at http://www2.ncsu.edu/effective_teaching

week. In the traditional arrangement, the professor lectured and a graduate teaching assistant conducted the laboratory using standard lab equipment. The purpose of the laboratory is usually to corroborate some result or fact previously discussed in the lecture or revealed in the laboratory manual. The laboratory is often conducted following "recipe" type instructions.

The integrated course consisted of three two-hour sessions per week. In the integrated approach the laboratory activities are done as they are needed and their results and findings discussed previous to their discussion in a lecture. The results and findings of the lab activities are used to inductively develop models and 'discover' the principles that govern Nature. This approach contrasted the traditional *teaching by telling* method by nicely blending lecture and laboratory periods to produce an active, integrated learning environment. The lecture-laboratory-integrated environment promotes active learning because the students participate in hands-on and brains-on activities. With this inductive approach, the students are involved in critical thinking adventures that prepared them to pose and formulate better questions and to supply more thought-filled answers. This approach capitalizes on the student's natural curiosity. It emphasizes both discovery and exploration allowing students to proceed from the concrete to the abstract. The integrated approach uses standard lab equipment, but it also makes use of Calculator-Based Laboratory™ (CBL) technology. With the CBL, the graphing calculator (TI-83) and the use of sensors, the course takes advantage of real-time data collection and analysis to introduce some of the concepts.

Figure 4. Test Scores Comparison
(Concept: Force of Friction)



Assessment of student's progress and the effectiveness of the approach included pre and posttest analysis of conceptual tests administered to students in both groups. Figure 4 shows the results of a study conducted in the course concerning the relationship of the impact of the teaching/learning style and the misconceptions of the friction concept. The samples consisted of students in the traditional course section and students from two integrated lecture/lab sections. The students in the integrated approach obtained better scores in the post-test, reflecting a better understanding of the topic.

D. Use of Graphic Calculators in SMET Courses

Thirty (30) faculty members from seven (7) PR-LSAMP participant institutions are currently integrating the application of graphic calculators and CBL systems in their SMET courses. Participants received a set of Texas Instruments calculator (TI-83), a user manual, in addition to participate in three applications workshops. This faculty is expected to integrate the use of the graphing calculators in their courses. At the time of this writing, eight (8) faculty had effectively integrated innovative activities and experiments applying the graphic calculator and CBL system.

VI. Conclusions

During its seven-year history, the Puerto Rico Louis Stokes Alliance for Minority Participation Project has been contributing in transforming our higher education system into a learning oriented community. To achieve its goals and objectives of increasing the number and the quality of underrepresented minorities in SMET disciplines, one of its components, the Curriculum Innovation Center, has carried on many activities. This Center has facilitated and promoted successful projects focused on assessment and revision SMET courses and programs. These have ranged from the assessment of topics covered in courses to the use of learning styles to enhance the teaching/learning in the classroom. It is evident that faculty and institutions that have actively participated in this project have effectively changed the outcomes in their SMET courses. Curricular revision and assessment has not been limited to the classroom, but has also led to the establishment of a scholastic community of SMET faculty committed to documenting and publishing educational research, strategies and results for the benefit of the academic community at large.

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Rosa Buxeda is Associate Professor of Biology at the University of Puerto Rico - Mayagüez Campus (UPRM). She received a BS degree in Industrial Microbiology from UPRM in 1985, a Master degree in Bacteriology from the University of Wisconsin in 1986 and a PhD from Rutgers University, New Brunswick in 1993. She was the former associate director of the UPRM Center for Professional Enhancement and former associate director of the Biology Department. For several years, Dr Buxeda was UPRM liaison officer of PR-LSAMP. She has been active in educational research and has published and offered workshops in cooperative learning, learning styles, portfolio and the use of peer mentoring in the classroom.

Moisés Orengo-Avilés is Associate Professor of Physics at the University of Puerto Rico, Mayagüez. He has a Ph. D. in Physics from Brown University in the experimental study of Magnetic Resonance in Glasses. He has been Associate Director of the Department and worked in the k-12 curricular revision for physics in the Puerto Rico Systemic Statewide Initiative (SSI). Presently he is directing the Center for Professional Enhancement, which covers all aspects of professional development including teaching, learning, evaluation, and research. His current research interest is on the understanding of student's misconception in physics and to investigate effective ways of overcoming them.

Rosa Betancourt de Pérez is Professor at the University of Puerto Rico. Her main responsibilities are the Teaching and Coordination of the Organic Chemistry Course and the General Chemistry Laboratory. Recently she has developed experiments for General Chemistry that are being included in a Laboratory Manual that will be published in 2000. These Student-Design experiments promote active learning and emphasize the process of doing chemistry and of data analysis. She has developed Modules for Cooperative Learning in Organic Chemistry and Interactive Demonstrations for Organic Chemistry. She is currently working on the development of General Chemistry Experiments that use the Graphical Calculator. Recent publications include: A PDR Problem for Sophomore

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José R. López is Full Professor of Physics at the University of Puerto Rico Mayag:uez Campus (UPRM). He obtained a BS in Physics in 1971 and an MS in Physics in 1977 both from UPRM and a PhD in Biophysics from Michigan State University in 1983. He is Director of The Institute of Physical Sciences for Teachers, a Tittle II sponsored professional development program for science teachers. He is also a member of the Curriculum Innovation Committee of the PR-LSAMP program and has been liaison officer of the PR-LSAMP program at UPRM since 1994 and a member of the UPRM Center for Professional Enhancement since its beginnings. For the past five years he has been promoting active teaching in Physics and the integration of technology to the science classroom. He has offered workshops in PR, the US, Canada and Argentina on the subject. At present he is actively involved in research in physics education and is consultant to the NSF sponsored Puerto Rico Statewide Systemic Initiative for reforming science and mathematics education from K-12.