

Remote Sensing and GIS Option: Integrating Research and The Learning Factory Model

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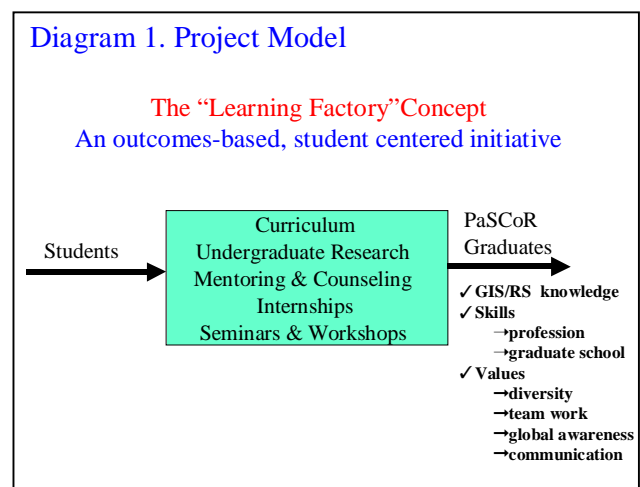
Abstract

The University of Puerto Rico at Mayagüez (UPRM) has established, through NASA Grant number NCC5-340, the *Partnership for Spatial and Computational Research (PaSCoR)*. The main goal of this 5-year project is to strengthen academic programs and integrate research at the undergraduate level in various science, math and engineering/technology (SMET) disciplines, following the strategy of the *Learning Factory* model implemented by the Manufacturing Engineering Education Partnership. The NASA PaSCoR program is outcomes-based and student centered, focused on hands-on learning activities provided throughout the student's academic career. The program's outcomes will be a graduate that is knowledgeable of the technology and applications of remote sensing (RS) and geographical information systems (GIS), and, possesses the necessary skills either to enter graduate school or becomes a professional in these areas with success.

The program also aims at developing values such as diversity, teamwork, global awareness and communication. PaSCoR goals will be achieved through five tasks, namely: 1) curriculum development, 2) undergraduate research & student mentoring, 3) industry collaboration, 4) outreach, and, 5) assessment. This paper describes the curriculum development strategy and expected major outcomes.

I. Background

The University of Puerto Rico at Mayagüez (UPRM) has established, through NASA Grant number NCC5-340, the *Partnership for Spatial and Computational Research (PaSCoR)*. The main goal of this 5-year project is to strengthen academic programs and integrate research at the undergraduate level in various science, math and engineering and technology (SMET) disciplines. The program follows the strategy of the *Learning Factory* model implemented by the Manufacturing Engineering Education Partnership (MEEP)^{3,6}. The PaSCoR program is being



developed in response to the need for skilled scientists and engineers in the areas of remote sensing and geographical information systems (RS/GIS). It is outcomes-based and student centered, incorporating undergraduate research and hands-on activities throughout the student's academic career. The program's outcome is a graduate that is knowledgeable of the RS/GIS technology and applications, and, possesses the necessary skills either to enter graduate school or becomes a professional in these areas with success.

The program also aims at developing values such as diversity, teamwork, global awareness and communication. PaSCoR goals will be achieved through five tasks, namely: 1) curriculum development, 2) undergraduate research & student mentoring, 3) industry collaboration, 4) outreach, and, 5) assessment. This paper describes the curriculum development strategy and expected major outcomes.

II. The PaSCoR Program

One of the principal objectives of PaSCoR is to provide an “*alternative track*” or “*option*” for undergraduate SMET students in the areas of RS/GIS, global positioning systems (GPS), data visualization, animation and analysis, and other related topics. This track or option will provide the student with non-traditional learning experiences in the new courses to be developed and those to be revised in four SMET programs (Electrical Engineering, Geology, Mathematics and Agricultural Sciences). By doing so, we aim to attract and retain students and provide a focus for preparing students for careers and graduate studies in these areas. This innovative program integrates an undergraduate curriculum with hands-on experience provided by exposure to laboratory activities and undergraduate research that spans the student's college years. The key element in this approach is the combination of curriculum revitalization with coordinated opportunities for application and hands-on activities. The courses to be developed and those to be revised will contain and balance content with “soft skills” development (for example, problem-solving, communication, teamwork). The students completing the course and research requirements will receive a certificate in RS/GIS.

Basically, students are introduced to the RS/GIS option early on. This is being done through various means:

- **Freshman Student Orientation Week.** PaSCoR faculty and advanced undergraduate students participate in this orientation session required for freshman prior to the beginning of the semester. RS/GIS option flyers are included in the student package.
- **UNIV 101 Freshman Course.** This course has been revised to include one lecture/presentation of PaSCoR opportunities. Approximately 2000 students take this course, which is required for all freshmen, every year. Here, PaSCoR faculty, paSCoR counselor or advanced undergraduate students make a presentation of the optional certificate and requirements

PaSCoR
...from Space

NASA - PAIR
UPR - Mayagüez

Partnership for Spatial and Computational Research
<http://ece.uprm.edu/pascor/>

Faculty

- Ramón Viquez
- Larry Murch
- Lee Jambor
- Robert Acar
- Pamela Iannata
- Leo Olivieri
- Héctor Pizarro
- Rosa Becerra
- Jorge Villan-Arenas

The purpose of PaSCoR is to provide minority institutions with an opportunity to build on their NASA-sponsored research and their rich history of educational excellence by strengthening the Mathematical, Science, Engineering and Technology (MSET) undergraduate academic infrastructure of the minority institutions.

PaSCoR will have an opportunity to create a multidisciplinary training environment by engaging a broad spectrum of the MSET faculty and by advancing classrooms of students preparing to become the next generation of scientists and engineers. The general topic will be in the study and use of remote sensing algorithm development and applications with the idea of creating a certificate program in remote sensing. Collaborations will be in the form of seminars, lectures and summer research internships at several universities and NASA space centers.

Throughout the collaboration with the Tropical Center for Earth and Space Studies at UPRM and their satellite downlinks, data will be provided that can extend our knowledge of Earth system changes in the Caribbean and their applications on the global scale.

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and invite students to consider registering. A list of students interested in participating is made.

- PaSCoR Recruitment Sessions.** At least, twice a year, these sessions provide an opportunity for students to hear presentations made by PaSCoR faculty on RS/GIS applications are distributed in order to select up to 45 students to become part of a research group.

Student applications are reviewed by the PaSCoR Executive Committee and students are selected based on the following criteria: high-school GPA, SAT scores, first semester college grades, with special attention to the Math courses, and the result of an interview with PaSCoR faculty. An effort is done to include students from all disciplines and both genders. One of the requisites for the selected students is that they participate in the [Summer Station Workshop](#). Besides making them aware of RS/GIS technology and applications, the purpose of this workshop is to initiate the development of research and other "soft" skills (such as oral & written communication, teamwork, and scientific methodology). Activities include workshops, seminars & presentations, field trips to RS/GIS industry or laboratories, culminating in a poster presentation.

http://ece.uprm.edu/pascor

Interdisciplinary teamwork & communication skills. Undergraduate research. Summer internships.

Remote Sensing And GIS Option for Science, Math & Engineering Students

RS/GIS

Putting NASA's Earth Science to Work. Remote Sensing Applications

Requirements: Minimum of 12 credits of courses and 6 credits in undergraduate research

Certificate: The S&E Department will issue a certificate upon completion of credit hours

For more information: Prof. Lussy Morel, INOU; Dr. Ramon Vazquez, INEL; Dr. Harold Pansani, INEL; Dr. Luis Jimenez, INEL; Dr. Pamela Jimenez, GEOL; Dr. Robert Alcar, MATH; Dr. Luis Olivera, AGS&C; Dr. Jorgelina Veloz, BIOL; Dr. Rosa Buxeda, BIOL; Ms. Josefina Gonzalez, ENGG OFFICE

This option has been developed thanks to the help of FEMA-340

Some RS-GIS New or Revised Courses in Engineering, Geology, Mathematics and Agricultural Sciences:

- UNIV 101
- Introduction to RS (required)
- Introduction to GIS (required)
- Application of RS/GIS in Agriculture
- Image Processing
- Pattern Recognition
- Signal Systems
- Images of Earth
- Geology in Earth Science
- Field Verification
- RS Topics in Mathematics
- Scientific Visualization
- Geology Intro Lab
- Geological Applications of RS
- Crop Production
- Soil Fertility
- Soil Chemistry
- Numerical Analysis
- Applied Stat. Analysis
- Undergraduate Research (required)

After the Summer Station, they register in the introductory PaSCoR courses and are then assigned to a faculty mentor and his/her research team. For various semesters students take their discipline courses and take PaSCoR courses as electives. They meet regularly with their faculty mentor and research team and have the opportunity to visit the PaSCoR counselor to help them with their difficulties and assist in the registration process. Students are also urged to participate in junior technical meetings organized and present their research findings. By their senior year, students are required to take 6 credit-hours of formal undergraduate research in the area of RS/GIS. More than 70 students are participating per year (40 freshman and 30 in undergraduate research). In addition, at least five (5) senior PaSCoR students are selected for paid Summer internships in laboratories or companies specializing in RS/GIS in mainland USA.

Finally, students who complete the 12 credit hours of PaSCoR courses and the 6 credit-hours of research are presented with the RS/GIS Certificate, offered by their respective departments.

The process is represented in the following Diagram 2 and Table 1.

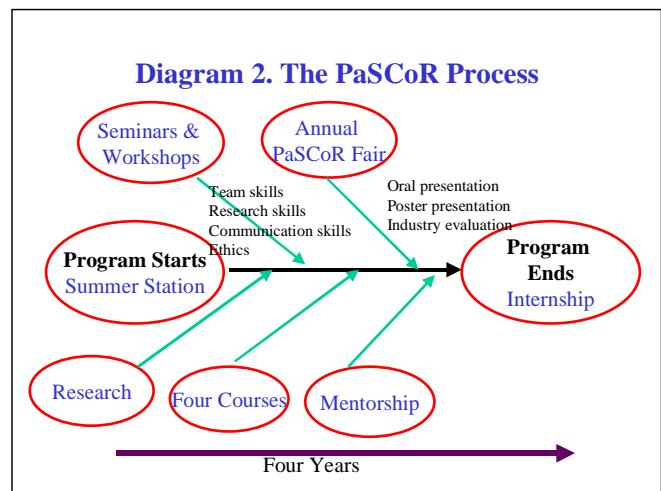


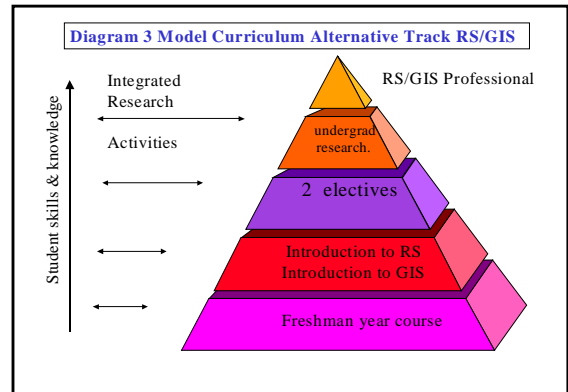
Table 1. PaSCoR Student Progress and Activities

YEAR/ ACTIVITIES	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Recruitment & Curriculum	<ol style="list-style-type: none"> 1. Awareness (1)¹ (Univ 101, other) 2. Selection of 35 students (1) 3. Mentor Assignment (1) 4. Seminars & Workshops (2) 	PaSCoR Courses <ul style="list-style-type: none"> • Int. to RS (1) • Int. to GIS (2) 	PaSCoR Courses <ul style="list-style-type: none"> • Advanced courses in SMET disciplines: Geology, Math, Agricultural Sciences, ECE 	
Undergraduate Research	<ul style="list-style-type: none"> • Summer Station Workshop (2) 	<ul style="list-style-type: none"> • Undergraduate Research with mentor in a team (advanced undergraduate students & faculty) 	<ul style="list-style-type: none"> • Undergraduate Research with mentor in a team (advanced undergraduate students & faculty) • Selection of 5 students for Summer Internships 	<ul style="list-style-type: none"> • Undergraduate Research with mentor in a team (advanced undergraduate students & faculty)
Outreach	<ul style="list-style-type: none"> • Technical Presentations in local, national & international forums (e.g., Junior Tech Meeting, CRC, ADMI, Annual PaSCoR Fair) 	<ul style="list-style-type: none"> • Technical Presentations in local, national & international forums (e.g., Junior Tech Meeting, CRC, ADMI, Annual PaSCoR Fair) 	<ul style="list-style-type: none"> • Technical Presentations in local, national & international forums (e.g., Junior Tech Meeting, CRC, ADMI, Annual PaSCoR Fair) 	<ul style="list-style-type: none"> • Technical Presentations in local, national & international forums (e.g., Junior Tech Meeting, CRC, ADMI, Annual PaSCoR Fair) • Submission of Paper for Publication • PaSCoR Research Presentation • RS-GIS Certificate Ceremony
Student Counseling	Academic & Professional Counseling (1,2)	Academic & Professional Counseling (1,2)	Academic & Professional Counseling (1,2)	Academic & Professional Counseling (1,2) <ul style="list-style-type: none"> • Graduate studies opportunities • PasCoR Job Fair • Job opportunities

¹ Numbers in parentheses refer to semester in the academic year (first or second).

III. The PaSCoR Curriculum

Our curriculum development strategy was adopted from the Manufacturing Engineering Education Partnership (MEEP)³. This strategy provides continuing curriculum contact with students, spans their entire college career, and integrates hands-on learning activities, skills development and industrial collaboration, as can be seen in Diagram 3. RS/GIS alternative track consists of 12 credit-hours (or the equivalent of four 3 credit-hour courses) that students take as electives in their respective programs of study. These courses will be complemented with 6 credit-hours of undergraduate research work in their senior year in the abovementioned research areas.



This new alternative track of courses integrates the use of laboratory facilities at UPRM, an “extended Learning Factory”, specifically the Laboratory for Applied Remote Sensing and Image Processing Laboratory (LARSIP) and the Spatial Information Laboratory (SIL) administered by the Department of Electrical Engineering. These laboratories and those existing at both the Geology and Mathematics departments are soon to be up-graded in order to accommodate the pool of students in the new track. The students who elect to complete this alternative track of courses, therefore, will be aided throughout their academic years by facilities that will allow them integrated learning experiences, which complement the class lectures.

Students will have the opportunity to participate in seminars, lectures and summer research internships at selected institutions and local/ national laboratories (e.g., NASA Space Centers). In addition, contacts with UPRM’s Tropical Center for Earth and Space Studies (TCESS), the Center for High Performance Computing at Mississippi State University and the University of Miami will generate opportunities for collaboration.

IV. PaSCoR Courses

The interdisciplinary curriculum will consist of a series of courses spanning the student’s entire academic career. At the freshman level, the freshman year course (University 101), a freshman requisite, is being revised to include concepts of RS/GIS. This will give the entire freshman class the opportunity to become aware of this technology and the opportunities and requirements of this alternative curriculum track, therefore, motivating students to consider the curriculum track.. Already this strategy is producing results. Ninety five percent (95%) of freshman students surveyed in the pilot sections of this course in academic year 98-99 showed interest in the program.

Ten (10) new courses are being created, and seven (7) are being revised at the Electrical & Computer Engineering, Mathematics, Geology and Agricultural Sciences departments to include RS/GIS concepts and applications. Table 2 shows the course description (new or to be revised), distribution by department, and expected student registration.

Table 2. Course Description

DEPARTMENT	COURSES
Freshman Year Course	<ul style="list-style-type: none"> ▪ University 101 (revised)
Electrical & Computer Engineering	<ul style="list-style-type: none"> ▪ Introduction to RS (new) ▪ Introduction to GIS (new) ▪ ECE 4xxx Fundamentals of Image Processing (new) ▪ ECE 4xxx Fundamentals of Pattern Recognition and Signal Analysis (new)
Geology	<ul style="list-style-type: none"> ▪ GEOL 3xxx. Images of Earth (new survey course—all majors) • GEOL 3047.Laboratory (revised) ▪ GEOL 4048. Geological Applications of Remote Sensing (revised) ▪ GEOL 5xxx GPS Geodesy in Earth Science (new) ▪ GEOL 5xxx Field verification (new)
Agricultural Sciences	<ul style="list-style-type: none"> ▪ CFIT 3005 Fundamentals of Crop Production (revised) ▪ AGRO 4018 Physical and Chemical Properties of Soils (revised) ▪ AGRO 4037 Soil Fertility and Fertilizers (revised) ▪ AGRO 5xxx. Application of remote sensing to agriculture (new) ▪ AGRO 4998 undergraduate research course (new area)
Mathematics	<ul style="list-style-type: none"> ▪ MATE 4061 Numerical Analysis (revised) ▪ ESMA 3xxx Statistical Data Analysis (new) ▪ COMP 4yyy Computer Graphics (new)

Several courses are being developed (or revised) during years 1 and 2 of the project; pilot tested during year 2 and 3 and institutionalized afterwards. Participating PaSCoR faculty have to undergo an intensive workshop to develop courses following a common template with regards to description, objectives, skills, activities and assessment. A major outcome of this workshop is the design of courses in a integrated and collaborative fashion to give coherence to the entire curriculum. Years 4 and 5 will be devoted to promoting the revision of other MSET courses to include RS/GIS concepts, by means of workshops and seminars offered to faculty. Faculty will be rewarded for developing and integrating RS/GIS examples and application modules in their SMET courses through small curriculum grants (\$500), therefore expanding and impacting other faculty and courses. This academic year, four faculty are participating responding to a request for proposal. The modules to be developed must follow the PaSCoR template described herein, and include student outcomes assessment strategy.

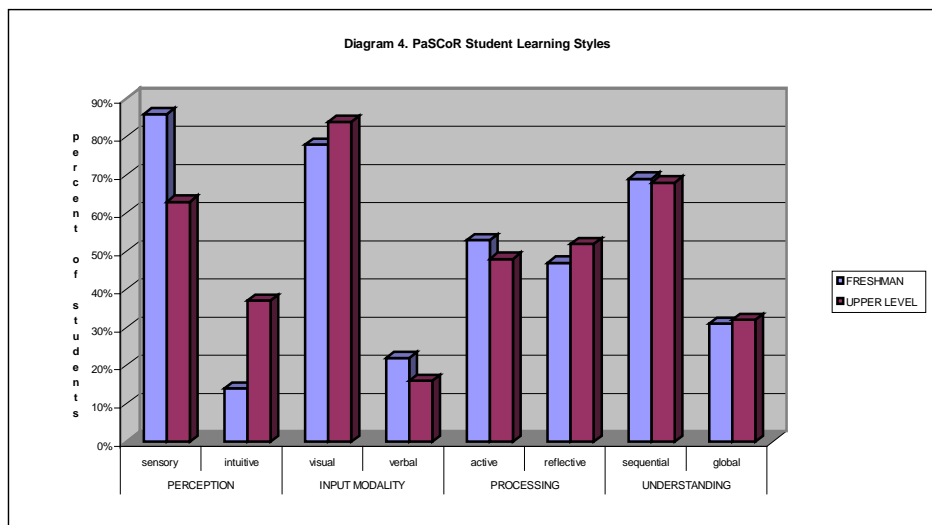
An innovative approach in course development is the use of the student profile for the design and development of class activities in PaSCoR courses. We are currently using Felder and Solomon Learning Styles Model² [http://www2.ncsu.edu/effective_teaching] to characterize our student population, and to develop specific course activities to address and respond to different learning styles. In academic year 1998-99, students presented the profile shown in Diagram 4. As can be seen, freshman students tend to be more sensorial than intuitive and more visual than verbal. Therefore, freshman level courses should include more visual aids and hands-on activities that enhance student learning. A similar approach was used in the design of classroom experiences in Science courses at UPRM¹. This data was used also in the design of the PaSCoR Summer Station.

IV. PaSCoR Summer Station

As mentioned before, selected students are required to take a 5-day intensive workshop, called the **PaSCoR Summer Station**. Its objectives are:

- To motivate and train first year undergraduate student from SMET disciplines in skills that will encourage them to pursue research in RS/GIS
- To familiarize them with the technology of RS/GIS
- To recognize the importance of RS/GIS
- To identify RS/GIS applications
- To interact with private and federal agencies using the technology in the workplace
- To develop team work and communication skills, and,
- To initiate a mentor relation with upper-level PaSCoR students and researchers.

The 5 days intensive workshop targets 40 freshman students from engineering (68%), science and math (17%), and agriculture sciences (15%). The weeklong activities include workshops on teambuilding skills, what is RS/GIS, RS/GIS scientific methodology, RS/GIS literature search, how to prepare and present a poster. Activities also include RS/GIS



research presentations by faculty. The interdisciplinary team had fieldtrips to US Geological Survey, Caribbean Pictometry and Tropical Center for Earth and Space Studies. Student documented their progress by daily reflection of the learning experience that initiates the PaSCOR student portfolio. The last day was the Poster Day where students presented a poster under the topic: "The PaSCoR Experience" A major component of the Summer Station was the use of the upper level PaSCoR student that were actively involved in research as mentors of the freshman team...

Assessment indicates that 100% will recommend the experience to a friend. Comments include; interesting and educational opportunity, unique, unforgettable and wonderful experience, exciting, it was great, challenging. Activities considered of higher impact were fieldtrips, teamwork, poster preparation, and RS/GIS applications.

V. Courses Template, Assessment and ABET 2000

All PaSCoR courses are being designed or revised in view of the new ABET 2000 criteria. The PaSCoR course syllabus follows the template depicted in Table 3, which follows the MEEP model^{4,5}. Each course will have the list of topics to be covered as well as the skills (e.g., teamwork, communication) to be developed, as per ABET 2000 criteria number 3, and the assessment strategy to evaluate student performance. Teaching and learning activities are designed to provide the student with the content knowledge as well the opportunities to develop the proposed skills. Therefore, traditional lectures are complemented with in-class demonstrations, laboratory experiences, consultations, field trips, and oral presentations and written reports. Students will be required to work in teams in projects and other activities. A learning style profile on the student population will be used in designing course activities to promote learning. In addition, a portfolio will be used to document the student learning process. PaSCoR faculty have been exposed to this new ABET 2000 criteria and assessment through NSF's PR-Alliance for Minority Participation (PR-LSAMP) workshops and seminars.

Table 3. PaSCoR Course Syllabi and Modules Template^{4,5}

<i>TOPICS</i>	<i>SKILLS TO BE DEVELOPED</i>	<i>TEACHING/LEARNING ACTIVITY</i>	<i>ASSESSMENT STRATEGY AND TOOLS</i>
Topic 1			
Topic 2			

VI. Industry and other Institutions' Collaboration

In order to achieve the expected curriculum outcomes, it is of utmost importance that industry and other partners become major stakeholders of the project. Their role in the educational paradigm is vital. Therefore, PaSCoR has created an Industrial Advisory Board, which is composed of respected industry representatives and faculty from US institutions. Our industry partnership will assist our undertaking in various ways, some of which are:

- Providing input and critique to our curriculum.
- Providing student projects.
- Assisting in the evaluation of student projects.
- Providing experts for lectures, seminars and workshops
- Providing summer internships for faculty and students.
- Providing jobs for our graduates.

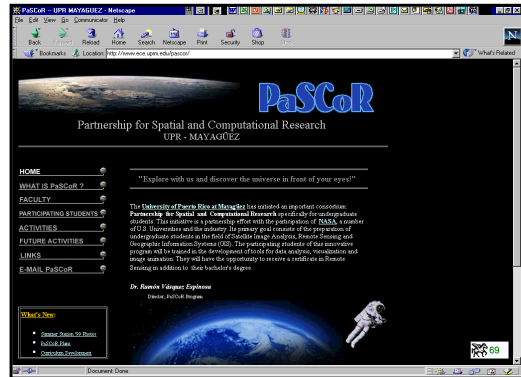
In addition, in order to place as many students in summer internships, MOU's are being sought from various local and national institutions. Some names of collaborators are: Raytheon, USGS, Trimble, Caribbean Pictometry, Inc. and NASA Stennis Laboratory. Locally, UPR-M collaborates with existing laboratories, such as the (e.g., through TCESS).

VII. Seminars & Workshops

It is of utmost importance for faculty and students to participate in workshops and seminars about RS/GIS topics if we want them to be up-dated in RS/GIS technology and applications. A series of these are offered during the year. These activities are open to all SMET faculty. In addition, PaSCoR faculty participate in a series of workshops and seminars in areas such as curriculum assessment, learning/teaching styles and the use of technology in education, thanks to the collaboration of the NSF funded Curriculum Innovation Center of the Puerto Rico Alliance for Minority Participation Program.

VIII. Outreach

Outreach activities to disseminate PaSCoR program results and the RS/GIS curriculum track and certificate include publication and dissemination of posters, brochures and a 10 minute video. Curricular materials will be disseminated to other MSET faculty through the PR-AMP program. A web page has been created (<http://ece.uprm.edu/pascor>) updated regularly and where we expect to post all curricular material as they become available. At the end of the project, a CD-ROM with all the curricular materials will be pressed and disseminated to interested parties. Finally, outreach to the academic community will occur through papers and presentations in national and international conferences.



IX. Conclusion

The PaSCoR program provides undergraduate students with valuable opportunities to acquire not only knowledge but also experience and skills in the RS/GIS areas, motivating them for careers and graduate studies in these areas. The major attributes of our curriculum are:

- Interdisciplinary focus, providing students and faculty to exposure to various SMET disciplines
- Balance between knowledge and skills/competency development
- Integrated research and laboratory experience
- Strong collaboration with industry
- Focused on the needs of tomorrow's workplace for this technology
- Integrates both student performance and outcomes assessment

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Ramón Vásquez-Espinosa, received his BS and MS degrees in Electrical Engineering from the UPRM and his PhD in Electrical Engineering from Louisiana State University in 1984. He is currently Full Professor of Electrical and Computer Engineering at the University of Puerto Rico - Mayagüez Campus (UPRM) and the Director of the Research and Development Center at UPRM. He is also the PI for the NASA Partnership for Spatial and Computational Research, a multi-disciplinary program to develop a RS/GIS option. His research interests include computer vision, image processing, remote sensing, artificial intelligence, VLSI and computer systems programming. He is one of the peer reviewers for various NSF and NASA programs. He is a member of PRS, IEEE, SPIE, ASEE, ASPRS and ACM, and various honor societies.

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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.