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ABSTRACT

This report describes a three-part effort by the Florida Postsecondary Education Planning Commission to identify some of the current outstanding efforts to improve science and mathematics at the postsecondary level and to explore ideas on how these positive practices can be expanded. Site visits to three selected postsecondary institutions (Chipola Community College, Florida Atlantic University, and Rollins College) show how these institutions have implemented strategies for improving science and mathematics on their campuses. Findings, based on the site visits and reviews of existing programs, include: (1) improvement is most effective when supported by an institution-wide commitment; (2) courses must be restructured to reflect a more active hands-on approach to learning that reflects real-world applications; (3) faculty members should be hired who reflect the new approaches to teaching in these areas; (4) faculty initiatives to develop collaborative efforts with elementary and high school students and teachers to improve science and mathematics learning should be encouraged; and (5) institutions that improve the retention and graduation rates of women and minorities majoring and graduating in the fields of science, mathematics, and technology-related fields should be rewarded with additional funding. Appendices include an institution nomination form and a summary of exemplary programs. Contains seven references. (MKR)

POSTSECONDARY EDUCATION PLANNING COMMISSION

Assessing Efforts to Improve Science, Mathematics, and Technology-Related Education at the Postsecondary Level

March 1993

State Board of Education
Postsecondary Education Planning Commission
Florida Education Center
Tallahassee, Florida 32399
(904)488-7894

POSTSECONDARY EDUCATION PLANNING COMMISSION

The Postsecondary Education Planning Commission, initially created by executive order in 1980 and subsequently given statutory authority (SS 240.145 and 240.147, Florida Statutes), serves as a citizen board to coordinate the efforts of postsecondary institutions and provide independent policy analyses and recommendations to the State Board of Education and the Legislature. The Commission is composed of 11 members of the general public and one full-time student registered at a postsecondary education institution in Florida. Members are appointed by the Governor with the approval of three members of the State Board of Education and subject to confirmation by the Senate.

The major responsibility of the Commission is preparing and updating every five years a master plan for postsecondary education. The enabling legislation provides that the Plan "shall include consideration of the promotion of quality, fundamental educational goals, programmatic access, needs for remedial education, regional and state economic development, international education programs, demographic patterns, student demand for programs, needs of particular subgroups of the population, implementation of innovative educational techniques and technology, and the requirements of the labor market. The capacity of existing programs, in both public and independent institutions, to respond to identified needs shall be evaluated and a plan shall be developed to respond efficiently to unmet needs."

Other responsibilities include recommending to the State Board of Education program contracts with independent institutions; advising the State Board regarding the need for and location of new programs, branch campuses and centers of public postsecondary education institutions; reviewing public postsecondary education budget requests for compliance with the State Master Plan; and periodically conducting special studies, analyses, and evaluations related to specific postsecondary education issues and programs.

Further information about the Commission, its publications, meetings and other activities may be obtained from the Commission office, 231 Collins Building, Department of Education, Tallahassee, Florida, 32399-0400; telephone (904) 488-7894; FAX (904) 922-5388.

POSTSECONDARY EDUCATION PLANNING COMMISSION

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A report prepared in collaboration with:

The Department of Education
Title II Eisenhower Mathematics and Science Education Program

National Science Foundation/Florida Department of Education
Statewide Systemic Initiative (SSI)

The Florida Chamber of Commerce

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CONTENTS

EXECUTIVE SUMMARY

During the past three years, a coalition of Florida business leaders, educators and policy makers worked together to design and help implement *A Comprehensive Plan for the Improvement of Mathematics, Science, and Computer Education* in the state's public and private schools, colleges and universities. One aspect of the Comprehensive Plan was a charge to the Postsecondary Education Planning Commission (PEPC) to "explore ways in which community colleges and universities can support the goal of becoming a world class leader in mathematics, science, and the use of computers in education."

To complete this charge, PEPC first sought to examine data on existing statewide programs and resources. In addition, with the assistance of the Florida Chamber of Commerce and Florida's Department of Education, a statewide call for nominations of current exemplary postsecondary education programs occurred and a competitive review process identified 10 programs. Finally, site visits to selected postsecondary institutions were conducted to assess implementation of the concepts contained in the *Comprehensive Plan*. While the three institutions visited deserve recognition for the excellent programs they offer, these three should be viewed as examples of several kinds of strategies and activities presently found at colleges and universities throughout Florida.

One aspect of the Comprehensive Plan was a charge to the Postsecondary Education Planning Commission (PEPC) to "explore ways in which community colleges and universities can support the goal of becoming a world class leader in mathematics, science and the use of computers in education."

Based on the site visits and reviews of existing exemplary mathematics and science programs throughout Florida, PEPC concluded that the following elements are essential to improving student learning in science, mathematics and technology-related fields:

- Improvement in mathematics and science education and improvement in the development of teachers for these fields are most effective when supported by an institution-wide commitment. Neither the Colleges of Education nor the Colleges of Arts and Sciences working separately

will provide the total answer. By the same token, universities are directly dependent on the quality of instruction taking place in these fields in the community college sector. This review also reinforced the fact that public and independent institutions have much to share with each other.

- Faculty must be willing to revamp and restructure courses in science and mathematics to reflect a more active hands-on approach to learning that reflects real-world applications of these fields. An example of such an approach is the program at **Chipola Junior College** for K-12 teachers that underscores the relationship between science and mathematical concepts and the practical application of those concepts to the space program at the National Aeronautics and Space Administration.

- College and university administrators must support applied learning practices and reward instructors who seek to improve their courses and curriculum. For example, at the institutions visited as part of this review, administrators understand and support the necessity of hiring faculty who have adapted their teaching styles to reflect a new approach to learning.

Faculty must be willing to revamp and restructure courses in science and mathematics to reflect a more active hands-on approach to learning that reflects real-world applications of these fields.

- To reinvigorate colleges of education and science, faculty members should be hired that reflect the new approaches to teaching in these areas. The existing early retirement program in the State University System (SUS) has not resulted in a significant number of openings and should be reexamined and possibly restructured so that faculty can afford to retire and new instructors - not teaching assistants or adjuncts - hired to take their place.

- Faculty initiatives to develop collaborative efforts to improve math and science learning with elementary and high school students and

teachers should be encouraged and rewarded as part of a faculty member's public service duties and responsibilities.

- Innovative programs supported by federal grants should not replace institutional commitment to improving the teaching of math and science. Grant programs that encourage minorities to major in certain high-tech fields could be adopted as institutional policy and implemented when possible with internal funding and support.

- Institutions that improve the retention and graduation rates of women and minorities majoring and graduating in the fields should be rewarded with additional funding (through either the Community College Program Fund or the State University System funding methodology).

- While inservice training and summer institutes are important components of retraining secondary teachers in mathematics and science, ongoing collaborative activities with area community colleges and universities are essential to integrating new teaching methodologies and curricula into elementary and high school programs. Regular follow-up reports and visits are necessary components of any summer or inservice training program.

Based on the conclusions drawn from its preliminary research, identification of exemplary programs and institutional site visits, PEPC recommends the following:

1) The Eisenhower Program and the National Science Foundation's Florida Statewide Systemic Initiative (SSI) Project should jointly support the establishment of consortia in the fields of mathe-

matics and science involving faculty representatives from all postsecondary sectors. Objectives would include:

- identification and refinement of standards for good practice and strategies for improvement of teaching and learning of mathematics and science, particularly for non-majors and at the lower division level, and
- collaborative pursuit of government, corporate and other support for applied and interdisciplinary curriculum development and faculty inservice training.

2) The Postsecondary Education Planning Commission, in cooperation with the Florida Chamber of Commerce and Florida's Department of Education, should pursue the identification of resources to continue the exemplary postsecondary mathematics and science program identification process, including the provisions of some recognition in the form of small financial awards to be used for costs directly related to improvement of the teaching/ learning experience.

Colleges of Education and Florida's Department of Education should work in tandem to revise and update the curricula required of elementary school teachers including the consolidation of certain methodology courses.

3) Both the development of Blueprint 2000 and the school improvement efforts of Florida's Department of Education should consciously incorporate and address the major goals and objectives of the Comprehensive Plan for Improving Mathematics, Science and Computer Education.

4) The Postsecondary Education Planning Commission, Education Standards Commission and sector boards should examine statewide certification requirements to make sure that there are no obstacles to adopting new teaching methodologies or curricula that reflect improved methods of student learning.

5) Colleges of Education and Florida's Department of Education should work in tandem to revise and update the curricula required of elementary school teachers including the consolidation of certain methodology courses. Curricula required of elementary education majors should include separate coursework in the disciplines of mathematics and science.

6) The Department of Education's Bureau of School Improvement and Instruction should work cooperatively with representatives from local school districts, community colleges and universities to design science and math degree programs to provide specialized training for elementary school teachers to provide specialized training.

BACKGROUND

In April, 1989 when the State Board of Education adopted the *Comprehensive Plan for the Improvement of Mathematics, Science and Computer Education in Florida*, it provided significant focus and direction to efforts to improve student learning in mathematics, science, and technology related subjects and skills.

Improvements in the delivery of science and mathematics at the postsecondary level beyond teacher education are necessary for the state and the country to achieve and maintain world class standards in these fields.

In the Fall of 1991, PEPC outlined a three-part approach to help "explore ways in which Florida's community colleges and universities can support the goal of becoming a world class leader in science, mathematics, and the use of computers in education" based on:

1) Examination of data on existing statewide programs and resources;

2) Identification of exemplary institutional programs and practices currently in place; and

3) Site visits to selected institutions to assess overall involvement in addressing the goals of the *Comprehensive Plan*.

In recent years, both nationwide and in Florida, considerable attention has been devoted to the improvement of teacher education with a particular focus on the fields of science and mathematics education. The summer inservice institutes, the six Centers for Excellence, and Eisenhower Title II grants are just a few examples of these efforts.

In developing the activities described in this report, a key assumption of PEPC was that improvements in the delivery of science and mathematics at the postsecondary level beyond teacher education are necessary for the state and the country to achieve and maintain world class standards in these fields. This report represents a preliminary step by PEPC to recognize some of the current outstanding efforts to improve science and mathematics at the postsecondary level and to explore ideas on how these positive practices can be expanded.

A review of the literature during this project indicated a consensus that change was necessary. Variations regarding how this should be accomplished were evident. **Kenneth Bruffee**, Director of the Scholars Program of Brooklyn College, believes that science must be taught more the way it is done - more collaborative, more conceptually intriguing and a lot less tidy. The curriculum must involve less closed-end, result-focused tasks and become more open-ended, integrative and inquiry based. The challenge lies in not only addressing the numbers of students choosing to major in science and math, but also in encouraging the more intellectually adventurous students to enroll beyond the introductory courses.

Sheila Tobias isolated characteristics associated with effective science education reform efforts. When positive change occurs it is less likely to be top-down, external expert driven and more frequently attributable to broad-based, local commitment and the reallocation of resources at the department level. Sustained funding is often entirely internal. A sense of community is important. Small classes encourage more active participation by students but, where this is not practical, personal rather than mechanistic grading practices are essential. Faculty involved in positive change are not waiting for the traditional reward structures to be modified. They are engaged because it is the right thing to do. Administrators are discovering the power of the "little r" - the small reward for a job well done - which may take the form of recognition, or small monetary incentives designed to directly enhance the teaching/learning experience.

When positive change occurs it is less likely to be top-down, external expert driven and more frequently attributable to broad-based, local commitment and the reallocation of resources at the department level.

Interdisciplinarity is a common theme. An increasingly popular textbook, *Great Ideas in Physics* by Massachusetts Institute of Technology professor **Alan Lightman**, moves beyond mathematical equations to discuss the impact of the scientific principles on the work of such non-physicists as **Immanuel Kant**, **Edgar Allan Poe**, **Vladimir Nabakov**, and historian **Henry Adams**.

Many of the concepts touched upon here were reinforced during the course of this project and contributed to the conclusions and recommendations found in the following pages.

The current effort was truly a collaborative endeavor. PEPC is indebted to several groups and individuals for their commitment of time and resources including the:

Florida Chamber of Commerce
for their sponsorship of the process to identify and recognize exemplary postsecondary programs,

Department of Education Office of Planning and Budgeting (which oversees the postsecondary component of the Title II Eisenhower programs) for its support of the institutional site visits, and the

National Science Foundation/Florida Department of Education Statewide Systemic Initiative (SSI) for supporting the postsecondary science and mathematics education process and for editing, designing and publishing this report.

EXAMINATION OF EXISTING PROGRAMS

Beginning in the Fall of 1991, PEPC staff met with representatives of the Department of Education, the Florida Chamber of Commerce, Florida's National Science Foundation Statewide Systemic Initiative (SSI), and both the K-12 and postsecondary components of the Title II programs supported by the Eisenhower Mathematics and Science Education Act. In addition, PEPC staff participated in meetings of the SSI State Advisory Council, the advisory committee responsible for overseeing implementation of the *Comprehensive Plan*, and the Annual Title II Symposium. During this time, the administrator of the postsecondary Title II program initiated steps to improve the request for proposals, grant selection and evaluation procedures related to programs funded from this source. This activity addressed questions raised by PEPC and others concerning the lack of information on the impact of previous grants. Examples of data sources and documents examined included: PEPC's study of colleges of education, the Education Standards Commission's evaluation of the preparation of elementary school teachers, reviews of science and mathematics programs by the State Board of Community Colleges and Board of Regents, the *Blueprint for Career Preparation*, an evaluation of the Regional Centers for Excellence, and A Mathematics, Science, and Computer Education Report Card which evaluated progress in implementing the *Comprehensive Plan*. The initial examination of existing resources and information provided the foundation for subsequent activities.

IDENTIFICATION OF EXEMPLARY PROGRAMS

During April, 1992, the Florida Chamber of Commerce, Florida's Department of Education, and the PEPC jointly issued a *Call for Nominations* (**Appendix A**) to identify programs and activities within Florida's public and independent colleges and universities which support the State's goal of becoming a world class leader in science, mathematics, and technology-related education. Responses were received from all sectors, as well as from several other entities including the National Aeronautics and Space Administration and the Florida Solar Energy Center. A total of 25 nominations were reviewed by a panel of representatives from business and industry, public and independent postsecondary institutions, school districts and the Department of Education (**Appendix B**). **Major criteria** used in the review included: **program effectiveness, transferability, and cost**.

Chipola Community College, Florida Atlantic University and Rollins College foster an environment that is conducive to creativity and cooperation among all departments and with other educational institutions in their area.

The ten programs chosen by the Committee were:

1) **Rollins College**
   The Science Community Year (SCY);
2) **Florida Institute of Oceanography**
   NEPTUNE: Teacher Enhancement Training in Ocean Sciences;
3) **Rollins College**
   Institutes for the Advancement of Science and Mathematics Teaching;
4) **Florida Atlantic University**
   Advancing Learning in Science for At-Risk-Students in Grades 4 and 5;
5) **St. Thomas University**
   Summer Institute: Hands-On Problem Solving in Mathematics and Science;
6) **Florida State University**
   Young Scholars Program (YSP);
7) **Chipola Junior College**
   Restructuring the Teaching of Mathematics Through

the Use of Calculators;

8) **University of Central Florida**
Florida Solar Energy Center - Florida Middle School Energy Education project (FMSEEP);

9) **Indian River Community College**
Modeling and Problem Solving; and

10) **Chipola Junior College**
Integrating the Teaching of Mathematics and *Science Through Hands-On, Applied Problems in Space Science.*

A brief description of each program selected, including who to contact for more information, is included in **Appendix C**.

Representatives of all of the programs were formally recognized by the Florida Chamber at a luncheon in September 1992. In addition, the Florida Association of Science Teachers (FAST) provided program information to their members at the FAST annual conference in October, 1992.

SITE VISITS

The third phase of this project - visits to a sample of selected postsecondary institutions - took place during 1992. The purpose of the site visits was twofold: 1) to learn more about the exemplary programs and 2) to understand how the overall commitment and leadership at the institutions made such innovative programs possible. Due to time and resource limitations, three institutions, representing the major postsecondary sectors - public community colleges, state universities, and independent colleges and universities - were asked to provide the visiting team with examples of how four broad strategies for improving science and math were being addressed on their campuses. Those strategies, reflected in Florida's *Comprehensive Plan* and related national efforts, such as **Project Kaleidoscope** are:

The purpose of the site visits was twofold: 1) to learn more about the exemplary programs and 2) to understand how the overall commitment and leadership at the institutions made such innovative programs possible.

1) *restructuring introductory courses in science and mathematics for all students,*
2) *setting specific goals to increase minority and women baccalaureates in science and mathematics,*
3) *establishing a long-range plan to sustain a campus-wide science community, and*
4) *making formal connections with teachers and students in near by elementary or secondary schools.*

The three institutions selected, **Chipola Community College, Florida Atlantic University** and **Rollins College**, were also chosen because they reflect varied organizational and geographic settings. All three are unique and distinctive centers of education that share a common commitment to advancing and improving science and mathematics learning. Above all, they foster an environment that is conducive to creativity and cooperation among all departments and with other educational institutions in their area. The visiting teams and institutional representatives interviewed are listed in **Appendix D**. While these institutions deserve recognition for the excellent programs they offer, these three should be viewed as examples of several kinds of strategies and activities presently found at colleges and universities throughout Florida.

ROLLINS COLLEGE

The first site visit on October 5, 1992 was to Rollins College where two programs, 1) *The Science Community Year (SCY)* and 2) *Institutes for the Advancement of Science and Mathematics Teaching*, were chosen as examples of exemplary efforts to improve science and mathematics education. As with the other institutions, team members focused on the total learning environment at Rollins, while also keeping in mind the four broad educational strategies listed on page 12.

RESTRUCTURING. Rollins began an overall restructuring process seven years ago. Until that time, instruction was primarily conducted in the traditional lecture mode. To bring a new vigor to math and science courses and to encourage students to major in these disciplines, faculty began to revamp and restructure some of their curricula and teaching methods. Calculus is an area which is being restructured due in part to under-prepared students, and gradual transformation of the calculus courses into algebra reviews. The new course is now organized around small group activities rather than lectures, and includes tests that ask for answers in English rather than formulas. Software is being developed to enable students to concentrate on understanding the application of calculus rather than just the computations. A recent initiative, started with support from Fund for the Improvement of Postsecondary Education, is the Quantitative Learning and Teaching Program and Center. A model for quantitative reasoning across the curriculum is being developed. Nine departments, including both "hard" and social sciences, see a need for improved problem solving abilities. Peer consultant training, for both faculty and students, are provided.

ESTABLISH A LONG-RANGE PLAN TO SUSTAIN A CAMPUS-WIDE SCIENCE COMMUNITY. Rollins has operated a campus-wide Community of Learners program for ten years. The Science Community Year (SCY) Project was influenced by this as well as the work of **Sheila Tobias** and **P. Uri Treisman**. The project involves faculty members enrolling in introductory science and

mathematics courses as Master Learners. For example, an English Professor who is also the President Emeritus of the college, enrolled in general biology and pre-calculus courses. Benefits of this approach include increased motivation for students and teacher alike. For instance, having a colleague in class can only motivate the instructor to carefully consider teaching strategies while Master Learners can empathize with students in class. Faculty who are Master Learners are more aware of the interconnectedness of various disciplines, for instance, the importance of verbal and written communications skills for engineers, or the philosophical and ethical underpinnings of our scientific endeavors.

The SCY program also supports first-year college students taking science and mathematics courses. The goal is to develop a mutually supportive community of science students who are less likely than their peers to drop out of science courses and majors before graduation. The program achieves this goal by providing students with support including: peer tutoring, field trips, integrative seminars, and other activities fostering the formation of a four-year science support community. The SCY program, in effect at Rollins College for three years has had good results, some unanticipated. An unusually large number of minority students and women have participated, and the program stimulated science and mathematics curriculum innovation at the college.

The project at Rollins College, involves faculty members enrolling in introductory science and mathematics courses as Master Learners.

SET SPECIFIC GOALS TO INCREASE UNDERREPRESENTED STUDENT POPULATIONS IN SCIENCE AND MATHEMATICS BACCALAUREATES. SCY has demonstrated appeal to both women and minorities through its emphasis on a caring and nurturing environment. However, no specific goals for participation were established. Faculty members noted an increase in participation by Asian students in the sciences in recent years.

MAKE FORMAL CONNECTIONS WITH TEACHERS AND STUDENTS IN NEARBY SCHOOLS AND THE COMMUNITY AT LARGE. Rollins maintains more than a dozen projects involving local schools. The Institute for the Advancement of Science and Mathematics Teaching was recognized as an exem-

plary program. The Institute involves science, mathematics and education faculty and models applied learning techniques. Programs typically include teaching college level concepts, as well as activities geared to the elementary grades, that use these concepts. The Program for Improving the Science Preparation of Elementary Teachers was designed to improve the science content knowledge of elementary education majors through a series of science content courses introduced into the curriculum. Instruction in all of these courses emphasizes hands-on, process-oriented science which highlight the discover nature of science. Based on these principles, a summer institute for practicing teachers was developed.

Based on the Rollins College site visit, some preliminary implications for state-level consideration were developed:

- For a relatively small (1,441 full-time undergraduate students and a total full-time equivalent enrollment of 2,600) institution, Rollins College has an impressive variety of strategies in place for the improvement of science and mathematics teaching and learning. Any state-level funding or planning initiatives should recognize the potential of the independent sector to make a significant contribution and include it accordingly.

- Although Rollins' size and history are well suited for the types of interdisciplinary efforts that are in place, there is no reason why strategies such as the Science Community Year could not be adopted for use in public community colleges, universities and possibly high schools.

- While some work is being done, the President suggested that greater use could be made of laboratory facilities during the summer for collaborative projects involving public school students and teachers, as well as college and university faculty.

CHIPOLA JUNIOR COLLEGE

The site visit to Chipola Jr. College took place on October 9, 1992. Two programs: 1) *Restructuring the Teaching of Mathematics Through the Use of Calculators*, and 2) *Integrating the Teaching of Mathematics and Science Through Hands-On, Applied Problems in Space Science*, were chosen as exemplary examples of how activities within Florida's colleges and universities are enhancing Florida's leadership role in mathematics, science, and technology related education. In addition to these two initiatives, many departments and programs reflect Chipola's dedication to an integrated, active approach to learning across all disciplines and within the community at large.

RESTRUCTURING. Perhaps the best example of innovative teaching methods at Chipola can be found in the "hard sciences" and mathematics. The award winning program, **Restructuring the Teaching of Mathematics through the Use of Calculators**, was initiated by the faculty as a process to restructure the teaching of mathematics to strengthen learning. Through the integration of graphing calculators into the mathematics courses, students improved their understanding of mathematical concepts. Final exams changed from being numerically oriented to conceptually oriented, and the mathematics department developed a one-hour credit course that uses problem situations to encourage students to explore, formulate and test conjectures, to prove generalizations, and to communicate and apply the results of their investigations. As a result of their success, the faculty have presented this approach to approximately 400 teachers in 18 Florida counties.

Working together, faculty members reorganized three chemistry, one biology and one zoology course, separating the laboratory from the lecture portion. This reduces the necessity of repeating the laboratory when satisfactory progress is not met in the lecture portion of the course. Faculty also purchased computers and programs in chemistry, physical science and physics to broaden the base of experiments and student involvement.

ESTABLISH A LONG-RANGE PLAN FOR A CAMPUS-WIDE NATURAL SCIENCE COMMUNITY. To develop a more integrative science and mathematics curricula, faculty in those disciplines regularly take one another's courses. For instance, when the calculus professor takes a physics course and vice versa, their students benefit from an increased awareness of the relationship between these two subjects. In introductory biology courses, the curriculum now focuses on the human body as an example of vertebrate anatomy, physiology and development. This approach provided a good background for allied health majors and stimulated interest among non-science majors without sacrificing the substance required for science majors.

MAKE FORMAL CONNECTIONS WITH TEACHERS AND STUDENTS IN NEARBY ELEMENTARY OR SECONDARY SCHOOLS. Chipola implemented dual enrollment courses at 11 of its 15 district high schools. Those courses allow students to complete prerequisite introductory courses while in high school. Chipola faculty holds yearly meetings with dual enrollment teachers and shares teaching materials and software with their high school counterparts. The college sponsors an annual Mathematics Olympiad for 15 high schools in the district and provides regular visits for elementary school students to biology, chemistry and physics labs to experience science demonstrations.

Chipola's award winning program, *Integrating the Teaching of Mathematics and Science Through Hands-on, Applied Problems in Space Science*, provides opportunity for K-12 teachers to strengthen science and math curriculum by increasing their knowledge of space science. In addition, the teachers design problem solving lessons that make use of high-tech equipment. The secondary and middle school teachers also focus on issues that cause students, especially minorities and females, to avoid math and science courses. One indicator of the project's success is that 15 area students applied for the Huntsville Space Camp this year. Three years ago there were no applicants.

SET SPECIFIC GOALS TO INCREASE MINORITY AND WOMEN BACCALAUREATES IN SCIENCE AND MATHEMATICS. Chipola faculty have worked cooperatively with the Panhandle Center for Excellence to cosponsor a one-day drive-in workshop for area teachers and students. Teachers each invited two female students to the workshop. The guest speaker was **Eileen Collins**, a female astronaut. In addition, faculty presented two reports - *Shortchanging Girls, Shortchanging America* and *Implications for Minority Participation* - to teachers who participated in the 1992 Title II Saturday Workshops. They discussed strategies to overcome problem areas at their schools.

In Spring 1992 Chipola sponsored a one-day conference to encourage female students in the eighth and ninth grades to continue to study science and mathematics and to pursue science related careers. Teachers from the 15 secondary and two middle schools were invited to bring ten female students from each grade to the conference. Participants heard from former mathematics teacher, a chemist and attended three career workshops.

Later that summer, science and math faculty sponsored a program for female students and their teachers that emphasized strategies to assist the students in science and mathematics classes. Through a Sex Equity Grant, Chipola sponsored a week-long workshop for female students and their mathematics teachers. The workshop provided opportunities for students to learn spatial skills, use laboratory equipment, discuss different ways of analyzing problems and explore mathematics topics through hands-on activities. Follow-up activities will determine if out-reach programs make a difference in recruiting girls for majors in science and mathematics. Based on the Chipola Junior College site visit, some preliminary implications for state level consideration were developed:

- Chipola faculty and administrators maintain a strong academic collaboration with the area elementary and secondary schools. This relationship not only strengthens the articulation of students into higher education but operates as a continual learning and sharing experience for faculty and teachers. Scarce resources and innovative teaching techniques are shared between sectors resulting in an impressive atmosphere of

congenial collegiality. While the small community lends itself to this type of arrangement, the collaborative approach can be duplicated at other institutions.

- Chipola faculty are willing to experiment with teaching techniques and are eager to expand their own knowledge base. This "lifelong learning" approach is a key element in revitalizing the teaching of science and mathematics.

- While Chipola has sponsored several impressive seminars and workshops to encourage female students to major in the sciences and pursue a career in those fields, it is imperative to follow-up on these initiatives to ensure that these students enroll in and graduate with the prerequisites for continuing in an appropriate major or career.

FLORIDA ATLANTIC UNIVERSITY

The site visit took place on October 30, 1992 in Boca Raton. Florida Atlantic University (FAU) has a large service area in one of the fastest growing parts of Florida. Faculty within the Colleges of Education and Science are building partnerships with both the K-12 and community college in an effort to restructure the science and math curriculum for education majors. Faculty in these disciplines are working with local teachers to cultivate students' interest in science, mathematics and technical education.

RESTRUCTURING. Faculty in Florida Atlantic's College of Education Department of Teacher Education have developed projects and initiatives to improve the knowledge and teaching skills of elementary school science and math teachers. These federally funded projects involve faculty at FAU as well as teachers and principles in the university's five county service region. One of the projects, an exemplary program, is geared to provide Advanced Learning in Science for At-Risk Students in Grades Four and Five. To improve the learning skills of children, teacher education majors take courses designed to build core concept knowledge in science and develop a repertoire of skilled, hands-on science activities and ideas of how to integrate reading and writing as part of science. Teachers completing the program receive direct follow-up support through classroom visitations, modeling science lessons and additional seminars. Thus far, 67 teachers in 23 schools have taken part in this initiative to improve advanced learning in science among fourth and fifth graders. Test results indicate that fifth grade participants have displayed significantly greater academic growth in science and reading than students in the control group.

In 1988 the Board of Regents authorized FAU to develop "experimental delivery systems and partnerships with area community colleges and school district's within existing authorized degree programs." As a result, FAU, Broward Community College, and Broward County Public Schools are now collaborating in the creation and implementation of an experimental teacher education program that exists along with other current programs. The new

program will be geared toward redefining the outcomes of teacher training - what teachers need to know and be able to do in this rapidly changing world. Technology will play a major role in the curriculum and delivery systems of the experimental program. Public school "best" teachers will be identified as "mentors" in teacher preparation and will use procedures developed by the representatives of the three collaborating institutions. Although recruitment for the program has already begun, the first students in the alternative preparation program will begin classes in Fall 1993.

Faculty in various science departments throughout the College of Science have revamped their introductory biology, chemistry, and life science courses to reflect a more interdisciplinary approach to learning and to enhance the real understanding of non-science majors who in the past have had difficulty making connections between the sciences and their broader learning experiences in college.

SET SPECIFIC GOALS TO INCREASE UNDERREPRESENTED STUDENT POPULATIONS IN SCIENCE AND MATHEMATICS BACCALAUREATES. One of the most effective ways to recruit minority students for science and mathematics programs at FAU is through the Southeastern Consortium for Minorities in Engineering (SECME). SECME is a coordinated effort involving 28 universities and 50 corporations in eight southeastern states. There are 20,000 students at 60 school systems actively involved in SECME. Eighty-five percent of SECME high school graduates plan to enroll in college and of these, 46 percent enter engineering, science, or math based majors. Rather than concentrating only on the "A" and "B" students, as many pre-college programs may be doing, the SECME approach seeks out young people who demonstrate aptitude and/or interest and helps them to realize their potential.

SECME institutions, with the commitment of the presidents, serve as support systems for the local school districts by providing faculty members as consultants who help to open the colleges' resources to the SECME students and teachers. Local industry, as well as the postsecondary institutions, offer tours and provide guest speakers who will visit the schools. In addition to field trips, design contests and science fairs are offered throughout the year.

FAU's Office of Pre-Collegiate Programs has initiated and expanded many innovative initiatives that encourage students to take charge of planning ahead for their academic and career paths. Many of the programs are geared to increasing the number of minority and female students who seek academic and career paths in fields of science, mathematics and technology. One of the programs, *Expanding Horizons*, was developed to increase the awareness of middle school female students and their parents to career options and appropriate academic preparation leading to high-tech and non-traditional careers. Emphasis is placed on the importance of higher-level science and mathematics courses to meet the workplace demands of the 21st century.

One of the active student societies at FAU is the Society for Women Engineers. One focus of the organization is outreach. Members regularly speak to high schools students about engineering education and career opportunities for women. Finally, aggressive recruiting of minority and female engineering students has enabled FAU to enroll and graduate a higher percentage of these groups than the national average.

ESTABLISH A LONG-RANGE PLAN TO SUSTAIN A CAMPUS-WIDE SCIENCE COMMUNITY. By beginning to revise academic curricula to reflect a more hands-on participatory approach to learning and by seeking collaborative relationships with local industry and surrounding school districts, FAU is aggressively experimenting with new and innovative approaches to learning as well as career development. Faculty within the College of Education and the College of Science plan to increase communication and shared resources to provide a more solid academic background for elementary and high school teachers. At the same time, the university has a strong administrative commitment to enhance the level of teaching and learning for all students regardless of major.

MAKE FORMAL CONNECTIONS WITH TEACHERS AND STUDENTS IN NEARBY SCHOOLS AND THE COMMUNITY AT LARGE. FAU's Technology Connection brings high school and middle school students and their teachers to campus for two-week sessions to learn about the five engineering laboratories

on campus. After learning how to use the equipment, students act as lab assistants in teaching these same materials to students in the session which immediately follows. The program culminates with a design contest among all student participants. The end results of this program are a group of students eager to come to college and major in engineering and a group of teachers better equipped to teach real-world applications of math in their classes.

Both the Pine Jog Environmental Educational Center (within the College of Education) and the Regional Center of Excellence provide ongoing inservice training for teachers of mathematics, science and computer technology. Pine Jog has contracted with the School Board of Palm Beach County since 1972 and provides environmental education programs to approximately 40 percent of all schools in Palm Beach County. Other services include inservice training and workshops for area teachers, and educational opportunities for adults, families, and local organizations. One of the most innovative outreach initiatives at FAU is the Chemistry Club's program to *"Improve Scientific Literacy and Interest at College and Elementary School Levels Simultaneously."* Developed by Chemistry Club students, the program involves undergraduate chemistry majors in performing simple experiments with students in several third grade classes in a large local elementary school on an ongoing basis. Groups of three to five undergraduate students meet with their assigned third grade class each month to demonstrate experiments in basic chemistry and physics using household items. Efforts are made to coordinate these experiments with the material currently being covered in the third grade science curricula. Preliminary results of an evaluation of the project indicate that it has improved the self-esteem of the undergraduate students involved and increased interest in scientific careers among students at all levels.

Based on the Florida Atlantic University site visit, some prelimi-

nary implications for state-level consideration were developed:

- *It is possible for universities to forge alliances with the K-12 sector to improve learning skills among elementary and high school students but it takes more than just faculty initiative or federal grants. Deans and administrators must reward faculty for taking the time to provide a meaningful "service" to this segment of the educational community.*

- *Faculty in both the Colleges of Education and Science have shown a willingness to cooperate in order to improve the curriculum for education majors. Faculty in the sciences are taking steps to revitalize curriculum for non-science majors.*

- *The university is committed to improving the recruitment and retention of women and minorities in the sciences as students and as instructors.*

- *The pre-collegiate program office is an excellent example of aggressive planning to improve the skills and choices for high school students before they attend a university or college.*

CONCLUSIONS AND RECOMMENDATIONS

The nationwide reform movement to improve student learning in science, mathematics, and technology-related fields has had a significant impact in Florida schools, colleges and universities. Indeed, Florida is assuming a leadership role in developing new approaches to the teaching of science, particularly at the elementary school level. This review of statewide postsecondary learning initiatives revealed that not only have some institutions improved and expanded programs that train school teachers, but have revamped courses to improve the science literacy of all students.

To develop courses that reflect the real-life application of science, mathematics, and technology, professors must be willing to rethink their teaching methods as well as outcome measures. This effort takes dedication, time and often more resources. It also takes a commitment from university administrators - from the president to the deans of colleges. Cooperation among faculty and within departments is crucial. Communication with K-12 teachers and administrators is essential. The philosophy that education is or should be a seamless ongoing experience from kindergarten through college is an important key to making the connection between a fifth grader's success in an earth science class to her later success in a college physics class.

Based on the three site visits and reviews of existing exemplary science and mathematics programs throughout Florida, the following conclusions appear to be key to improving student learning in science, mathematics and technology-related fields.

- Improvement in science and mathematics education and improvement in the development of teachers for these fields are most effective when supported by an institution-wide commitment. Neither the Colleges of Education nor the Colleges of Arts and Sciences working separately will provide the total answer. By the same token, universities are directly dependent on the quality of instruction taking place in these fields in the

community college sector. This review also reinforced the fact that public and independent institutions have much to share with each other.

- Faculty must be willing to revamp and restructure courses in science and mathematics to reflect a more active hands-on approach to learning that reflects real-world applications of these fields. An example of such an approach is the program at Chipola Junior College for K-12 teachers that underscores the relationship between science and mathematical concepts and the practical applications of those concepts to the space program at the National Aeronautic and Space Administration.

- College and university administrators must support applied learning practices and reward instructors who seek to improve their courses and curriculum. For example, at the institutions visited as part of this review, administrators understand and support the necessity of hiring faculty who have adapted their teaching styles to reflect a new approach to learning.

- To reinvigorate colleges of education and science, faculty members should be hired that reflect the new approaches to teaching in these areas. The existing early retirement program in the SUS has not resulted in a significant number of openings and should be reexamined and possibly restructured so that faculty can afford to retire and new instructors - not teaching assistants or adjuncts - hired to take their place.

- Faculty initiatives to develop collaborative efforts to improve science and math learning with elementary and high school students and teachers should be encouraged and rewarded as part of a faculty member's public service duties and responsibilities.

- Innovative programs supported by federal grants should not replace institutional commitment to improving the teaching of math and science. Grant programs that encourage minorities to major in certain high-tech fields could be adopted as institutional policy and implemented when possible with internal funding and support.

- Institutions that improve the retention and graduation rates of women and minorities majoring and graduating in the fields of science, mathematics and technology-related fields should be rewarded with additional funding (through either the Community College Program Fund or the State University System funding methodology).

- While inservice training and summer institutes are important components of retraining secondary teachers in mathematics and science, ongoing collaborative activities with area community colleges and universities are essential to integrating new teaching methodologies and curricula into elementary and high school programs. Regular follow-up reports and visits are necessary components of any summer or inservice training program.

Based on the above conclusions, the following recommendations were developed:

1) The Eisenhower Program and Florida's NSF/SSI should jointly support the establishment of consortia in the fields of science and mathematics involving faculty representations from all postsecondary sectors. Objectives would include:
   - identification and refinement of standards for good practice and strategies for improvement of teaching and learning of science and mathematics, particularly for non-majors and at the lower division level; and
   - collaboration and pursuit of government, corporate and other support for applied and interdisci-

plinary curriculum development and faculty inservice training.

2) PEPC, in cooperation with the Florida Chamber of Commerce and Florida's Department of Education, should pursue the identification of resources to continue the exemplary postsecondary science and mathematics program identification process including the provisions of some recognition in the form of small financial awards to be used for costs directly related to improvement of the teaching/learning experience.

3) Both the development of Blueprint 2000 and the school improvement efforts of Florida's Department of Education should consciously incorporate and address the major goals and objectives of the *Comprehensive Plan for Improving Mathematics, Science and Computer Education*.

4) The Postsecondary Education Planning Commission, Education Standards Commission and sector boards should examine statewide certification requirements to make sure that there are no obstacles to adopting new teaching methodologies or curricula that reflect improved methods of student learning.

5) Colleges of Education and the Florida Department of Education should work in tandem to revise and update the curricula required of elementary school teachers including the consolidation of certain methodology courses. Curricula required of elementary education majors should include separate coursework in the disciplines of science and mathematics.

6) The Florida Department of Education's Bureau of School Improvement and Instruction should work cooperatively with representatives from local school districts, community colleges and universities to design science and math degree programs to provide specialized training for elementary school teachers.

This document represents an initial step by PEPC to recognize and support initiatives leading to the improvement of science, mathematics, and technology-related education at the postsecondary level. Implementation of these review recommendations is in progress.

APPENDIX A

1992
CALL FOR NOMINATIONS

FLORIDA CHAMBER
of Commerce

March 2, 1993

Dear Education Leader:

Three years ago, the Florida Chamber of Commerce joined the Florida Department of Education in proposing goals and actions to improve our students' performance in math, science and computer education. The mission was clear-cut -- to make Florida a leader in math, science and computer education by 1999.

The Florida business community is interested in knowing how far we have progressed toward this ambitious goal. One of the milestones we would like to assess is how much has changed in the preparation of our future math and science teachers. To be specific, what is your institution doing to support Florida's goal of becoming a world-class leader in mathematics, science and the use of computers in education?

Please take a few minutes to look over the nomination sheet and share with us your exemplary mathematics, science or instructional technology programs. These programs can be located in museums, education centers, colleges or universities. If you submit more than one nomination, please have your institution's president rank which program(s) are the most innovative and effective.

Thank you for sharing your success with Florida's business leaders and educators.

Sincerely,

Pam Davis
1992 Chairman
Florida Education &
Industry Coalition

Florida Chamber of Commerce, Inc.
• 904 425 1260

CALL FOR NOMINATIONS

Exemplary Mathematics and Science Quality Programs in Postsecondary Education

A Cooperative Initiative of The Florida Chamber of Commerce, National Science Foundation/Florida Department of Education Statewide Systemic Initiative (SSI), and The Postsecondary Education Planning Commission (PEPC)

BACKGROUND

In April 1989, the State Board of Education adopted Comprehensive Plan for this Improvement of Mathematics, Science and Computer Education in Florida. A product of a joint task force of business leaders and educators, the Plan has provided significant focus and direction to efforts to improve student learning in mathematics, science, and technology related subjects and skills. Among the Plan's recommendations was a charge to PEPC to "explore ways in which community colleges and universities can support the goal of becoming a world class leader in mathematics, science and the use of computers in education."

ABOUT THE CALL FOR NOMINATIONS

As part of its upcoming master planning process, PEPC will examine the current status of efforts within Florida postsecondary institutions to support the State goal of achieving leadership in mathematics, science, and technology related education. The CALL FOR NOMINATIONS provides an opportunity for PEPC, in collaboration with the Florida Department of Education, the Florida Chamber of Commerce, the National Science Foundation/Florida Department of Education Statewide Systemic Initiative (SSI) Project, and others to collaboratively identify programs and activities within Florida's colleges and universities that enhance the state's leadership role in mathematics, science, and technology related education.

ELIGIBILITY OF NOMINEES

Programs or activities implemented by public and independent postsecondary institutions in Florida.

RECOGNITION CATEGORIES

Exemplary programs - established programs with documented success.

Promising programs and practices - new initiatives that have not been formally reviewed or are of shorter or limited duration such as workshops or competitions.

GENERAL CRITERIA

Comprehensive efforts with measurable results which address the State's efforts to achieve distinction in mathematics, science and technology.

Programs and practices which are creative, cost effective, transferable, and improve student learning and achievement.

Programs that target students such as women and minorities who have been traditionally underrepresented in math, science and technology-related careers.

Examples of effective use of instructional technology.

RECOGNITION

Successful nominees will be profiled in a statewide publication, and further recognized by the co-sponsors.

NOMINATION FORM

Exemplary Mathematics and Science Programs
in Postsecondary Education

INSTITUTION NAME:
CONTACT PERSON:
TITLE:
ADDRESS:
PHONE:
PROGRAM TITLE:
SUBJECT AREA:

Please provide the following information for the nominated program or practice in five pages or less:

I. Program Description
   A. Goals/Objectives
   B. Students Served - type and number
      (such as gender, race, limited English proficiency, disabled)
   C. Community Involvement
      (Describe outside agency or business involvement if appropriate.)

II. Program Effectiveness
   (Describe efforts to track program results and evidence that it is achieving its objective.)

III. Program Transferability
   (Describe need for training, special equipment/facilities or other factors related to replication of the program.)

IV. Program Cost
   A. Funding sources
   B. Start-up costs
   C. Operation/continuation costs

NOMINATION SUBMITTED BY (Name):
ADDRESS (If different from above):
CITY:
ZIP CODE:
DATE SUBMITTED:
SIGNATURE OF PRESIDENT
(Optional if submitted by someone other than the institution)

PLEASE RETURN THE NOMINATION FORM BY MAY 29, 1992 TO:

Florida Postsecondary Education Planning Commission
Florida Education Center
Tallahassee, Florida 32399-0400
(904) 488-7894

APPENDIX B

NOMINATION REVIEW COMMITTEE MEMBERS

NOMINATION REVIEW COMMITTEE

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APPENDIX C

SUMMARY OF EXEMPLARY PROGRAMS

Based on the committee's review, the following postsecondary programs were also selected for recognition:

Rollins College - The Science Community Year (SCY)

Supports first-year college students taking science and mathematics courses - potential science majors. The goal of the SCY program is to develop a mutually supportive community of science students who are less likely than their peers to drop out of science courses and majors before graduation. The program achieves this goal by providing students with support including peer tutoring, field trips, an integrative seminar, and other activities fostering the formation of a four-year science support community. The SCY program has been in effect at Rollins College for three years with good results, some of which were unanticipated: an unusually large number of minority students and women have participated and the program has had a stimulating effect on science and mathematics curriculum innovation at the college. **Kathryn Hickman**, Program Director: (407)646-2547

Florida Institute of Oceanography - NEPTUNE: Teacher Enhancement Training in Ocean Sciences

Created in 1984, NEPTUNE is an inservice program designed to provide teachers with experiential and field learning opportunities to increase their understanding of science concepts and to demonstrate through actual experience, scientific method and the critical evaluation of data. This enables teachers to use material in their classrooms without an over-dependence on textbooks. To date, NEPTUNE programs have served nearly 550 teachers in grades K-12 from 35 public school districts. **Dean Milliken**, Program Director: (813)893-9100

Rollins College - Institutes for the Advancement of Science and Mathematics Teaching

Designed to improve the science content knowledge of elementary education majors through a series of science content courses introduced into the curriculum. Instruction in all of these courses emphasizes hands-on, process-oriented science which highlight the discovery nature of science. A summer institute for practicing teachers was also developed based on these principles. Evaluations using cognitive and affective measures consistently show improve-

ment in the participants' attitudes toward science and their science content knowledge. **Linda DeTure**, Program Director: (407)646-2242

Florida Atlantic University - Advancing Learning in Science for At-Risk Students in Grades 4 and 5

Focuses on teacher training and college coursework designed to enhance elementary teachers' knowledge and understanding of core science concepts and related methodologies for providing and integrative curriculum strategy for at-risk students. Effectiveness of the strategy is evaluated from the standpoint of achievement, affective, and other performance outcomes of the at-risk students. Thus far, grade 5 participants have displayed significantly greater growth in science and reading than the control group. **Nancy Romance**, Program Director: (407) 367-3583

St. Thomas University - Summer Institute: Hands-On Problem Solving in Mathematics and Science

Focused on 20 classroom teachers in grades K-6 and 25 high school chemistry teachers who are working primarily with inner city, minority, low-income, migrant, disabled, or at-risk students. These types of students were identified as having a critical need in the area of mathematical problem solving and scientific problem solving. The goal of each institute is to enhance the teaching skills of each participant and to increase the amount of classroom time dedicated to critical thinking, problem solving, and cooperative learning. A unit on awareness of the equity issues which often deter females and minorities from pursuing careers in mathematics and science is an integral part of each institute. **Sally Mayberry**, Program Director: (305)628-6539

Florida State University - Young Scholars Program (YSP)

An academically intensive, six-week residential summer program in science, mathematics, and computer science for gifted and high-achieving high school students. The program was developed in 1983 to support and encourage promising Florida students to pursue careers in these fields. The YSP includes a mix of formal instruction, field trips, and research participation. The emphasis throughout is on problem solving and the integration of theory with hands-on application. Career exploration seminars provide students with new

insights into career possibilities and the academic preparation required. **Pat Hayward**, Program Director: (904)644-6747

Chipola Junior College - Restructuring the Teaching of Mathematics Through the Use of Calculators

Initiated by the faculty as a process to restructure the teaching of mathematics to strengthen learning for understanding. Through the integration of graphing calculators into the mathematics courses, students improved their understanding of mathematical concepts. Final exams changed from being numerically oriented to conceptually oriented, and the mathematics department developed a one-hour credit course that uses problem situations to encourage students to explore, formulate and test conjectures, to prove generalizations, and to communicate and apply the results of their investigations. As a result of their success, the faculty have presented this approach to approximately 400 teachers in 18 Florida counties. **Lou Cleveland**, Program Director: (904)526-2764

University of Central Florida/Florida Solar Energy Center - Florida Middle School Energy Education Project (FMSEEP)

A collaborative project whose primary purpose is to increase the amount of instruction about energy and energy-related environmental and economic issues in our middle schools. Instead of designing a program that just teaches about energy, the FMSEEP materials include a variety of environmental and economic issues. The instructional units were designed to supplement existing textbook and laboratory activities. A second product is the *Energy Research Project Guide* for students. This is a generic guide on how to conduct a research project with an energy, environmental, or economic theme. In addition to the Florida Energy Office and the UCF Solar Energy Center project, support is provided by Florida's major utility companies. **David Block**, Program Director: (407)783-0300

Indian River Community College - Modeling and Problem Solving

Influenced by the recommendations of the National Council of Teachers of Mathematics, the college developed a course which provides students with the knowledge and techniques on how mathematics is used to solve "real-world" problems. This course was presented to college students, high school students at a sum-

mer math institute, and employees of local companies. A special version of this course was developed for and taught to area middle and high school mathematics teachers. Evaluations from all audiences have praised the course for making mathematics more relevant and interesting. **William F. Ward**, Program Director: (407)468-4700, Ext. 4571

Chipola Junior College - Integrating the Teaching of Mathematics and Science Through Hands-On, Applied Problems in Space Science

Provides an opportunity for K-12 teachers to strengthen science and mathematics curriculum by increasing their knowledge of space science. In addition, the teachers and faculty cooperatively design problem solving lessons that make appropriate use of high tech equipment. The secondary and middle school teachers also focus on issues that cause students, especially females and minorities, to avoid the study of mathematics and science. Working cooperatively with other teachers, participants have developed hands-on, integrated lessons using materials from NASA and the Young Astronauts Program. One indicator of the success of this project is that 15 area students applied for the Huntsville Space Camp this year. As recently as three years ago there were no applicants. **Lou Cleveland**, Program Director (904)526-2764

APPENDIX D

VISITING TEAMS AND INSTITUTIONAL REPRESENTATIVES

ROLLINS COLLEGE

VISITING TEAM

Dr. Pat Dallet, Assistant Executive Director, Postsecondary Education Planning Commission

Mr. Bill Howden, Director of Government Relations United Technologies, West Palm Beach

Mr. Jay Feliciani, President, Florida Science Teachers Association and Pasco County

Dr. George Dawson, Director, National Science Foundation (NSF) Interactive Media Science Project, Florida State University

INSTITUTIONAL REPRESENTATIVES

Dr. Rita Bornstein, President, **Dr. Linda DeTure, Dr. Eileen Gregory, Dr. Nancy McAleer, Dr. Robert Carson, Dr. Thaddeus Seymour, Dr. Thomas Cook, Dr. J. Douglas Child, Dr. Roger Ray, Dr. Larry Eng-Wilmot, Dr. Greg Alman** , Dr. David Marcell, and Dr. Donald Griffin

CHIPOLA JUNIOR COLLEGE

VISITING TEAM

Dr. Glenda A. Rabby, Policy Analyst, Postsecondary Education Planning Commission

Lew Wager, Policy Analyst, Department of Education

Mr. David Stewart, Advanced Project Manager, Rockwell Space Systems, Kennedy Space Center

Dr. Mark Pritchett, Vice President, Florida Chamber of Commerce

INSTITUTIONAL REPRESENTATIVES

Dr. Jerry W. Kandzer, President, **Mr. David Nicholson, Dr. Lou Cleveland, Dr. Francis Breivogel, Ms. June Eubanks-Mays, Ms. Joann Everett, Mr. Paul Huang, Ms. Charlene T. Lord, Ms.**

Fauline Mathis, Dr. Stephen Shimmel, Mr. Clifford Lewis, Mrs. Carol Cool. Public School representatives: **Mr. PhilFlater, Ms. Charlotte Gardner, Ms. Rose Cabin**

FLORIDA ATLANTIC UNIVERSITY

VISITING TEAM

Mr. Bill Howden, Director, Government Relations, United Technologies, West Palm Beach, Florida

Dr. Glenda A. Rabby, Educational Policy Analyst, Postsecondary Education Planning Commission

Ms. Bettye Roth, Mathematic Curriculum Specialist, Palm Beach County Schools, Palm Beach Gardens, Florida

Lew Wager, Education Policy Analyst, Department of Education

INSTITUTIONAL REPRESENTATIVES

Dr. Anthony Catanese, President, **Dr. Nancy Romance, Dr. Leonard Berry, Dr. Jerry Haky, Dr. Mark Jackson, Dr. Herb Stewart, Dr. Bob Shockley, Dr. Charles Carraker, Dr. Lucy Gugielmino, Dr. Rick Osburn, Ms. Carla Coleman, Ms. Pat Welch, Dr. Sharon Schlossberg, Ms. Jean Goodwin, Dr. Arnold Mandell, Dr. Heinta-Oho Peitgen, Dr. James Brewer**

APPENDIX E

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REFERENCES

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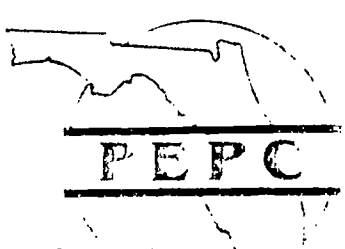

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