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Model Program for the Recruitment and Preparation of High Ability Elementary

Mathematics/Science Teachers:

A Collaborative Project Among Scientists, Teacher Educators and Classroom Teachers

#### **Abstract**

This teacher education program will provide a model for recruiting, educating and retaining high ability students to become mathematics and science lead teachers in elementary schools. The quality experiences and support provided these students will help them develop the knowledge and attitudes necessary to provide leadership for elementary mathematics and science programs. Students will have research experiences at the Ames Laboratory, high quality field experiences with nationally recognized mathematics and science teachers in local schools and opportunities to meaningfully connect these two experiences. This program, collaboratively designed and implemented by scientists, teacher educators and classroom teachers, should provide a replicatable model for other teacher education institutions. In addition, materials developed for the project should help other laboratories interface more effectively with K-8 schools and help other teacher education programs incorporate real science and mathematics experience into their curriculum.

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# Model Program for the Recruitment and Preparation of High Ability Elementary Mathematics/Science Teachers:

A Collaborative Project Among Scientists, Teacher Educators and Classroom Teachers

# Background

As we strive to improve science and mathematics education for our nation's young people, more attention must be focused on elementary school teachers. Traditionally, individuals attracted to elementary teaching have not had strong backgrounds in mathematics and science. Numerous authors have suggested that this situation may create negative initial experiences in mathematics and science for young children. Currently, there is much interest in attracting and retaining elementary school mathematics and science specialists to teach and lead in elementary school environments.

The specialist teachers need to have strong content area backgrounds in order to provide the type of curriculum leadership so needed in the elementary school. Ideally, these specialist teachers have had the opportunity to understand the nature of science and the scientist and to participate in the research experience. Typically, however, these types of experiences would not be available to teacher education students.

"Elementary school teachers...are drawn primarily from the three quarters of the population who dropped mathematics after two or three courses in high school. For many prospective elementary school teachers, their high school experiences with mathematics were probably not positive. Subsequently, teachers' ambivalent feelings about mathematics are often communicated to children they teach." (NRC, 1989, p. 2017 The idea of using mathematics and science specialists at the elementary level has been around for several years. Dossey cites Educating Americans for the 21st Century (1983) and its suggestion that school systems "assign interested teachers at the 4-6 grade level to become specialists as several mathematics..."

The NCTM Board of Directors supported this need in 1981 by recommending to state certification agencies that they make "provision for a mathematics specialist endorsement on teaching credentials for elementary teachers" (Dossey, 1983). Lichtenberg, in 1986, agreed

with Dossey. "With the ever-expanding elementary schools curriculum, keeping up with the demands of one subject alone is enough. Given the multitude of stimuli to which children are currently accustomed, we can no longer assume that only one teacher is needed for all subjects. People who know mathematics, like mathematics and like to teach mathematics to children should be the ones to teach mathematics" (Lichtenberg, 1986).

But the strongest and loudest support of specialists comes from Everybody Counts. "The United States is one of the few countries in the world that continues to pretend--despite substantial evidence to the contrary--that elementary school teachers are able to teach all subjects equally well. It is time that we identify a cadre of teachers with special interests in mathematics and science who would be well prepared to teach young children both mathematics and science in an integrated, discovery-based environment. The United States must create a tradition of elementary school specialists to teach mathematics and science." (NRC, 1989, P. 64-65)

Probably the single document in the science area that will have the greatest impact on curricular changes is the "An Agenda for Action in PreCollege Science Teacher Education Reform" paper. The paper clearly states that science curricular reforms are presently being performed by two professional associations: the National Science Teachers Association and the American Association for the Advancement of Science through their respective programs entitled, <u>Project Scope</u>, <u>Sequence</u>, and <u>Coordination</u> (NSTA) and <u>Project 2061</u> (AAAS).

The projected growth of <u>Project Scope</u>, <u>Sequence</u>, and <u>Coordination</u> and <u>Project 2061</u> will necessitate new models of pre-service teacher preparation. Much already has been written about the changes needed in pre-service teacher preparation. Among the influential groups affecting NSTA's thinking are the Holmes Group, Carnegie Commission, Project 30, the Renaissance Group, and the Consortium for Minorities in Teaching Careers. From the writings of these groups, NSTA has distilled six principles to guide them in suggesting exemplary preservice content preparation models. The six guiding principles for pre-service science teacher preparation reform were written to focus on two aspects of a comprehensive pre-service program: content preparation and the nature of knowledge. Two of these guiding principles were especially influential in conceiving the proposed project:

# Guiding Principle One

Every elementary-secondary science education pre-service student should experience the investigative nature of science.

# **Guiding Principle Two**

Every elementary-secondary science education pre-service student should have classroom and laboratory experiences in biology, chemistry, earth/space science, and physics.

The basic problem addressed in this project, then, is the need to attract, educate and retain high ability mathematics and science students so that they can assume a leadership role in developing and implementing elementary school curriculum. These students must have indepth science and mathematics content and pedagogy experiences during their undergraduate years so that they develop the understanding and appreciation of mathematics and science necessary to lead other teachers.

# The Proposed Program

The proposed program is a continuation of a project funded by the Department of Energy during the 1992-93 school year. For the second year of the project, activities developed during Year 1 will be continued and refined for a second and third cohort group of high ability students. Materials, lessons and approaches developed by students, teachers and scientists to link the world of the research scientist to 5th and 6th grade classrooms will be evaluated, compiled and made available for dissemination. In addition, high quality student teaching experiences focusing on mathematics and science teaching will be developed for project students who have completed Year 1 of the project. During Year 2, students who have participated in Year 1 of the project will help in recruiting both high school and college students for the project. Finally, all students in the program will receive opportunities to use state of the art technology to enhance the teaching and learning of science and mathematics.

In the proposed program, two cohort groups of high ability mathematics and science students will be identified and actively recruited for teacher education. In addition to completing the traditional requirements for elementary education majors, these students will be mentored by Ames Laboratory scientists and math/science educators, placed in high quality research and field experiences, and provided support and experiences through technology.

The cohort groups will be placed in science research experiences in the Ames Laboratory and will meet in seminar situations to discuss and share their science research experiences. Each semester, group members will prepare a sample lesson using their research experiences and applying them to an elementary school situation. These lessons will be executed in a field situation and shared with other elementary education students through videotape or class presentations.

Ames Laboratory scientists participating in the project will direct the students' involvement in a research project and work with the students to share results from the work with teacher education classes and elementary school teachers and students. Working together, the students, the Ames lab scientists, classroom teachers and teacher educators will prepare activity oriented lessons that communicate some of the parts of the student research experience.

The four classroom teachers working on the project during 1992-93 will remain with the project and four additional teachers will be added to the project staff. Classroom teachers selected for supervising project student field work will be selected on the basis of their performance in teaching mathematics and science. Master teachers in this area will be included in the project and each teacher selected will work with three project students. Master teachers will direct student work in the classroom, participate in seminars designed to help students transfer their science research experiences into classroom experiences for children and advise project staff. Project students will take a one-credit field experience course (280) each semester. Vitae of four of the teachers included in the project are included in the Appendix. Each participating classroom master teacher will be paid for his/her participation in the project.

The classroom field experiences provided for the students in the project will enable the students to actively work in classrooms where exemplary teaching of mathematics and science is occurring. Students will be in these classrooms for two hours each week and will serve as assistants to the master teacher during mathematics and science lessons. They will also have opportunities to present lessons based upon their research experiences. Students in this second year project will have the benefit of the materials and approaches developed by project

participants in Year 1. Master teachers will also serve as mentors to the students, providing discussion and rationale for various approaches used in the "real world" classroom.

Students selected for the project will receive stipends for their work in the laboratory (\$1000 per semester) and travel support to complete their field work with master mathematics and science teachers.

Project students will also participate in a 1-credit honors seminar each semester on mathematics and science education. The seminar will be directed by Drs. Glass and Thompson and will feature scientists, mathematicians, master elementary math and science teachers as guests. When the Advisory Board in Mathematics and Science Education considered the proposed project (January 22, 1992), members emphasized the need to help project students transfer their research experiences to the teaching of mathematics and science in the elementary school. This challenge will remain one of the major focal points of the project. One of the major purposes of this seminar experience will be to have scientists, classroom teachers and teacher educators help students tie their "real" science experiences to the world of the elementary classroom. Uses of technology in the teaching of mathematics and science will also be a strong theme in seminar work.

Academic advising for the cohort group will be shared by the teacher educators, subject matter specialists in academic departments and participating scientists. Students will be advised and encouraged to enroll in science and mathematics courses that provide both depth and breadth of experience.

During the 1992-93 academic year, project teachers, scientists and teacher educators worked cooperatively to determine how best to transfer student laboratory experiences to the classroom (see attached materials). Extensive time and energy were spent on sharing the worlds and cultures of the elementary classroom and the research laboratory between the teachers and the scientists. After numerous meetings in the classrooms and in the laboratories, teachers, scientists and teacher educators developed activities and ideas for bringing the world of the laboratory effectively into the classroom. The resulting activities, involving both scientists and participating teacher education students, represent sound attempts at integrating laboratory science into the current curriculum in the schools.

The curriculum development from Year 1 of the project will provide useful material for Year 2 project participants. The projects and activities developed from Year 1 will be shared with 1993-94 students to help them develop activities and approaches of their own. Thus, a growing collection of approaches and activities for connecting the laboratory and the classroom will be developed, refined, and published. These materials can then be shared with the other national laboratories and teacher educators. This growing collecting of ideas and materials should help the high ability project participants develop and refine their approaches to transferring the worlds of "real" science and mathematics to the classroom and help them assume leadership roles in science and mathematics education.

In addition to the development of specific classroom materials, a project research component added in Year 2 will enable the production of general Year 1 for enrichment of the existing elementary mathematics and science curriculum with activities and materials derived from the research laboratories of the Department of Energy. This thrust will develop guidelines for the integration of activities and people into existing science and mathematics curricula. The guidelines will be developed in such a way that they can be utilized in a wide range of projects in our nation's research laboratories.

#### **Project Goals:**

- 1. to attract and retain high ability mathematics and science students to elementary and middle school teaching
- 2. to provide research experiences for high ability preservice teacher education students and thus increase their understanding and appreciation of science and the scientist
- 3. to involve scientists, classroom teachers and teacher educators in the cooperative development and implementation of the project
- 4. to makes aspects of the model program available for all elementary teacher education students at Iowa State University
- 5. to measurably improve the science knowledge base of the participating students
- 6. to collaboratively develop and disseminate activities and materials to help meaningfully connect the "real science and math" of the laboratory to classrooms
- 7. to develop a set of guidelines for enrichment of the existing elementary mathematics and science curriculum with activities and materials derived from the research laboratories of mathematicians, scientists, and engineers.

8. to publicize the program in Iowa high schools and thus increase the pipeline of high ability students interested in pursuing careers in education

# The proposed program will include:

- a. extensive real mathematics and real science experiences for a selected group of high ability math/science students
- b field experiences with master mathematics and science classroom teachers
- c. technology used to enhance teaching/learning of math and science/including experiences with high performance computing
- d. recruitment initiatives designed to attract capable high school and college students to the program
- e. opportunities for students in the program to share their experiences and knowledge with all ISU teacher education students
- f. high quality, mathematics and science oriented student teaching experiences for second year project students
- g. published materials on activities, approaches, and guidelines that successfully integrate "real" laboratory experiences into the elementary school curriculum

The proposed model program provides means to recruit and prepare elementary school teachers with specializations in mathematics and science. The program is designed to identify and recruit potential pre-service teachers who have strong abilities in the math/science area and provide these students with a variety of content and pedagogy experiences that will equip them to take a leadership position in the teaching of mathematics and science in the elementary school.

The program emphasizes experiences in real science and mathematics for the select group of students and opportunities to relate these experiences to the world of the elmentary school classroom. Real science and mathematics experiences are are brought to students through two major methods:

- 1. Direct experiences with mathematicians and scientists at the Ames Lab and in the University
- 2. Use of technology to create mathematical and scientific experiences for the students

#### **Project Procedures**

Phase 1 of the project (Fall, 1992) focused on recruiting students for the program and identifying and training scientists to work with the students in the 1992-93 academic year. Students were actively recruited through mathematics and science department faculty, existing lists of high ability entering and returning students who had indicated possible interest in teacher education, and through academic advisors. In addition, the Office of Minority Student

Affairs helped in the recruiting efforts; since a current priority of this office is to recruit qualified minority students into teaching, that office is able to offer significant information and assistance.

Qualified students were asked to apply for the program, including information about their academic records, test scores, and extra-curricular activities. A team of scientists, classroom teachers and teacher educators evaluated the applications and choose 12 students for the program.

Scientists were identified by Connie Hargrave, Education Coordinator, of the Ames Laboratory. The scientists included Drs. Hugo Franzen, Kevin Dennis and Barb LaGrasso. Scientists met in seminars with Drs. Glass and Thompson, Ms. Hargrave, and project classroom teachers to determine content and procedures for the student experiences for the 1992-93 academic year. From these sessions emerged specific plans for both the research experiences and the lessons emerging from these experiences. As mentioned earlier, extensive time was spent during the Fall, 1992 in collaboratively developing project activities.

Phase 2 of the project, beginning in January, 1993 and ending in May, 1993, will include the student research experiences, seminars, classroom presentations, visits to high schools to recruit other students to the program, and project evaluation. Scientists, classroom teachers, and mathematics and science educators will continue to meet during the year to share discuss their project experiences and cooperatively create and test laboratory and classroom experiences for the project students.

Lessons created and presented by Ames lab scientists and project students will be videotaped and used as sample lessons for methods classes in the College of Education. These videotapes will also be shared with project staff as models and ideas.

Phase 3 of the project will occur during the summer of 1993. Scientists, teachers and teacher educators will continue to meet to evaluate Year 1 activities and compile sample lessons and approaches created during the 1992-93 school year. In addition, research and field experiences for Year 2 of the project will be planned during the summer.

Phase 4, the second academic year of the project, will focus on refining project experiences and providing activities for second year project students. During the proposed second year of the

project, a second and third cohort group of students will be identified for the project. Each semester, the cohort groups will participate in their research and field experiences and meet in the honors seminar described above. These students will use materials developed in Year 1 or the project as a base for the development of additional materials.

During 1993-94, several students from the initial cohort group will be student teaching. These students will be placed with outstanding science and mathematics classroom teachers and will be supervised by faculty with expertise in science and mathematics education. Students will use activities and approaches developed during the project in their student teaching and will include their scientist mentors in their student teaching classroom.

In addition to the exposure to math and science research projects, technology will be used throughout the students' programs to help bring relevant content and pedagogy to students. Early in their programs, students will take technology courses that should provide the background for using technology as a tool to learn and teach science and mathematics. Students will work with interactive multi-media, videodiscs, lab interfaces, and other tools to enhance their teaching and learning. In addition, students will create mathematics and science learning experiences for students using the high performance computing facility, funded by the Department of Energy, located in the College of Education. Instructors in both their content and methods classes will model uses of these technologies in the teaching process.

Dr. Lynn W. Glass, the co-principle investigator of the project proposed herein, was instrumental in developing the Macintosh mathematics and science curriculum handbook series. The present series focuses on applications utilizing microcomputers for effective teaching of secondary mathematics and science. An all new elementary mathematics and science curriculum series will be available this April from Apple Computer, Incorporated. This series will form the backbone for our technology focus.

# Project Personnel

Key personnel for the proposed project bring together a strong and varied set of backgrounds and perspectives. Dr. Lynn Glass, the past president of NSTA, brings extensive experience in science education (see vitae), while Dr. Thompson's areas of expertise include mathematics and technology education. Connie Hargrave is currently completing her Ph.D.

dissertation in the area of technology and science education. Three of the project master teachers have received national presidential awards for their math/science teaching efforts and most of the Ames Laboratory scientists participating the project have a strong record of previous involvement in K-12 education initiatives.

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Drs. Glass and Thompson will direct the recruitment portion of the project, facilitate the seminars, and organize the student field work. Dr. Thompson, chair of the Department of Curriculum and Instruction, will facilitate the incorporation of student lessons and projects into teacher education mathematics and science courses. Drs. Glass and Thompson will implement the evaluation portion of the project. Dr. Hargrave will organize and manage the student research experiences. All project personnel, including additional faculty from the College of Education and the mathematics and science-related departments at Iowa State University, will work together to share information and perspectives on creating a strong science experience for project students. The existing cooperative relationship of the Iowa State University College of Education, the Ames Lab and the Iowa schools will provide a strong base for project activities.

# **Project Outcomes**

Through the project, participating students will receive the opportunity to participate in "real" science and will also receive the support and guidance necessary to translate these experiences into lessons and activities appropriate for elementary school children. The experiences of these selected high ability mathematics and science students and the lessons created by them will be used to help bring these same "real" science experiences to the remaining students in the teacher education program at Iowa State University. Through these experiences, these high ability students will begin assuming a leadership and research role in science and mathematics education early in their careers.

Students in the program will experience high quality research experiences, elementary classroom experiences with master math and science teachers, and opportunities to share their experiences and thus strengthen the mathematics and science component of the entire teacher education program at Iowa State University. These experiences will help attract and retain the high ability students to teacher education and make them visible to other teacher

education students and to elementary teachers and students in the field. In addition, these high ability students will share their experiences with high school students to help recruit similar students to future programs. This visible and productive cohort group will serve to attract similar students to teacher education.

Materials developed for the project will be published and should provide a useful source of laboratory-based "real" science and mathematics activities for classroom teachers, preservice teachers and scientists. The guidelines developed during Year 2 of the project will be immediately useful to all DOE facilities engaging in educational work.

# **Project Evaluation**

Accomplishment of project goals will be both formatively and summatively evaluated during and following the project. Continuous formative evaluation will be used to shape the research experiences, seminars, field experiences, and presentation experiences. These evaluations will be used by project scientists and educators to continually modify and improve project student experiences. Lessons and activities developed in conjunction with the project will be tested, evaluated and modified as they are used in classrooms.

Summative evaluation will include data on retention and placement of project students, data on recruitment of additional high ability mathematics and science students, student project and presentation evaluations, and master teacher evaluations of the student and scientist produced lessons, and scientist evaluations of the students' research work. In addition, the participating students will complete questionnaires on all aspects of the project.

Both formative and summative data collected from the project will be included in research papers written for and presented at national meetings in science and mathematics education and teacher education. Both Drs. Glass and Thompson are regular presenters at national meetings including NSTA, AERA (American Educational Research Association), and NECC (National Educational Computing Conference). In addition, journal articles on the project and its results will be prepared and submitted to journals in science and mathematics education.

#### The Current Situation

Iowa State University of Science and Technology (ISU) is the oldest land-grant institution in the United States. With an institutional emphasis on areas related to science and technology, ISU provides high quality undergraduate programs across a broad range of disciplines. Located in Ames, it is one of three state-supported universities in Iowa and is administered by the State Board of Regents. Enrollment during fall semester 1991 was 25,250. The fall 1991 faculty roster listed 1,871 full- and part-time members.

The Department of Curriculum and Instruction (C&I) in the College of Education contains all the undergraduate teacher education programs in the university. Currently 1,019 undergraduate students are majoring in elementary education in the department, more than 90% of whom are female. There are approximately 500 additional undergraduate students who earn their secondary teaching licensure through the department and major in an academic department. Twenty four full time faculty are employed within the department, and six of these faculty members are specialists in the areas of science, mathematics or technology. In addition, 34 faculty members have joint appointments in C&I and in another academic department; of these joint appointments, four are from departments of mathematics or science. Department faculty in the area of mathematics, science and technology include a group of nationally recognized leaders in the field. In line with the university-wide emphasis on science and technology, strategic plans for the future of the college and the department include increased emphasis on research and development in teacher preparation in the areas of mathematics, science and technology.

Housed near the Ames National Laboratory, the department has a unique relationship with this Department of Energy research facility. Given the Department of Energy emphasis on science education projects, the Ames Lab has appointed Dr. Ann Thompson and Dr. Lynn Glass as Lab Associates for coordinating joint ventures with the College of Education. In several cooperative ventures, the department has used the personnel and facilities of the laboratory to provide "real science" and "real scientist" experiences to its pre-service and in-service teachers. Cooperative projects with the Ames Lab include a super computing laboratory for pre-service teachers funded by the Ames Laboratory, scientist presentations to pre-service and in-service

teachers, research and mentoring opportunities for preservice and in-service teachers at the Ames Laboratory.

The department is committed to providing a strong background in mathematics, science and technology to all its elementary pre-service teachers, and students take approximately 12 credits in mathematics and science content classes, as well as seven credits in mathematics and science methods of teaching classes and four credits of work in the area of technology in classrooms. Students choosing mathematics or science as an area of emphasis take approximately 24 credits of content work in the area. The department has recently formed an Advisory Board for its mathematics and science education program; the Board consists of teachers and administrators from K-12 schools, Iowa Department of Education mathematics and science directors, scientists, and Area Education Agency mathematics and science specialists. In addition, the department is in the process of constructing a model technology classroom for the teaching of mathematics and science methods to pre-service teachers. The classroom, jointly funded by the National Science Foundation and the Ames Lab, contains student computer stations including videodisc players, computer interface devices, laboratory equipment and sophisticated projection capabilities. the classroom will offer teacher education students the opportunity to both teach and learn using state of the art instructional technology.

#### Summary

In general, this program should provide a model for recruiting, educating and retaining high ability students to become mathematics and science lead teachers in elementary schools. The quality experiences and support provided these students will help them develop the knowledge and attitudes necessary to provide leadership for elementary mathematics and science programs. Students will have research experiences at the Ames Laboratory, high quality field experiences with recognized mathematics and science teachers in locally schools and opportunities to meaningfully connect these two experiences. This program, collaboratively designed and implemented by scientists, teacher educators and classroom teachers, should provide a replicatable model for other teacher education institutions. In addition, materials

developed for the project should help other laboratories interface more effectively with K-8 schools.

# References

Everybody Counts, National Research Council, 1989;

NCTM Curriculum and Evaluation Standards for School Mathematics, 1989;

A Call for Change, Mathematical Association of America, 1991;

NCTM Professional Standards for Teaching Mathematics, 1991;

NSTA Handbook, 1992-93, National Science Teachers Association;

An Agenda for Action in PreCollege Science Teacher Education, Lynn W. Glass (President of NSTA) and others, 1992

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