THE COMPREHENSIVE PROGRAM
FUND FOR THE IMPROVEMENT OF POSTSECONDARY EDUCATION

Form Approved
OMB No.: 1840-0514
Expiration Date: 10/31/93

TITLE PAGE

Preliminary X Final ____ Continuation ____

This application should be sent to:
No. 84.116A
U.S. Department of Education
Application Control Center
Room 3633
Washington, D.C. 20202-4725

1. Application No.

2. Employer Identification No.

3. Project Director
(Name and Complete Mailing Address)
Joseph Andrade, Ph.D.
Director, Center for Integrated Science Education (CISE)
2480 MEB, University of Utah
Salt Lake City, UT 84112
Telephone: 801 581-4379
Area Code and Number

4. Institutional Information
Highest Degree Level
____ Two Year
____ Four Year
____ Graduate
X Doctorate
____ Non-Degree Granting
Other: ____
X Public
____ Private

5. Federal Funds Requested:

1st Year Only	64,476
2nd Year (If Applicable)	63,476
3rd Year (If Applicable)	0
Total Amount:	127,952

6. Duration of Project: 2 years
Starting Date 9/93
Ending Date 8/95
Total No. of Months 24

7. Proposal Title: Science Without Walls -- Science Concepts and Skills for Elementary Teachers

8. Brief Abstract of Proposal: (Do not leave this blank)

We propose to design, develop, test, and implement *Science Without Walls (S W/O W)*, a concept-, inquiry-, and experiment-based course for elementary teacher candidates. *S W/O W* focuses on major science concepts, applicable to all science "disciplines." *S W/O W* is intentionally multi- and inter-disciplinary. *S W/O W* considers science as an integrated set of concepts and phenomena. With such concepts and understanding in hand, teachers can address science education at the K-9 level -- and have a strong, solid basis and comfort level for further studies in science.

We propose a 2 year program to develop, test, and implement *S W/O W* and to begin to disseminate the program and materials nationally.

9. Legal Applicant
(Name and Complete Mailing Address)
University of Utah
Salt Lake City, UT 84112

10. Population Directly Benefiting From The Project
100 undergraduate teacher education majors each year (200 total)
Congressional District(s)
Cong. Dist. # 2

11. Certification By Authorizing Official

The applicant certifies to the best of his/her knowledge and belief that the data in this application are true and correct and that the filing of the application has been duly authorized by the governing body of the applicant and the applicant will comply with the attached assurances if the assistance is approved.

JOSEPH D. ANDRADE
Name

Director, Ctr. for Integ. Sci. Ed. (801) 581-43
Title Phone

Signature

10/20/92
Date

Form ED 40-614, 5/92 Replaces Form ED0001, which is obsolete.

Project Description

Rationale and General Objectives:

The elementary school teacher is one of the most important professionals in our society today. It is he or she who educates the next generation, providing direction and motivation for the young. Elementary teacher candidates must develop an understanding and appreciation of science -- they must be genuinely comfortable with science concepts and methods in order to enhance the creativity and curiosity of their students. Elementary teachers require an integrated, coherent view of science and technology, of the scientific method, and of critical scientific reasoning.

We propose to design, develop, test, and implement *Science Without Walls (S W/O W)*, a concept- and inquiry-based course for elementary teacher candidates. *S W/O W* focuses on major science concepts, applicable to all science "disciplines." *S W/O W* is intentionally multi- and inter-disciplinary. *S W/O W* considers science as an integrated set of concepts and phenomena. With such concepts and understanding in hand, teachers can address science education at the K-9 level -- and have a strong, solid basis and comfort level for further studies in science.

The general concepts and topics for the 2 quarter, 20 week course are derived from two major sources:

1. the national reports and curricular reform movements which have proliferated in the last several years.
2. from interviews and interactions with high school science teachers, assessing their views as to the backgrounds which they feel students should obtain in the elementary school environment; and input from practicing scientists, engineers, and physicians, particularly the faculty at our own institution.

The themes to be covered, together with an understanding of student conceptions, fears, and their own perceived needs, will lead to the selection and the development of materials and modules for sensing and discovery of the key integrated concepts.

The general outline for the course is given in Table 1. The concepts experienced during the second term will also involve means of extending the students' senses, i.e., instrumentation and tools for observation and measurement.

We also propose the development of a third quarter independent research experience relevant to elementary and general science education.

We propose to implement these courses in stages. The initial implementation in year one will be for 25 nominated and selected elementary education majors. The 25 will be selected from a larger group of about 100 who will have filled out a needs, pre-conceptions, and interests survey.

Based on the experience with the first year group, we will then expand the course to the larger group of elementary education majors.

The basic approach to each two week concept module is given in Figure 1. The instructor would introduce and illustrate a key, integrated concept. This would be kept intentionally brief, and perhaps even preliminary. The students need, however, to have some indication or idea of where they are going -- some direction, which will be provided by the instructor(s)' introduction.

The instructor(s) then work with the class to identify areas of interest and background related to the concept, and assess pre-existing conceptions and misconceptions. The instructor must also know something about *each* of the individual students and about their major non-

scientific interests and motivations. It is very important to engineer the project so that it builds on the students' interests and backgrounds.

The initial class of 25 students will be organized into 5 groups of 5 students each. Each group, with the advice and recommendations of the instructors, will select an experimental approach to observing and discovering the concept in question. Admittedly, this will be a little difficult for the first concept or two.

In some cases the groups will be able to use existing experimental modules, which are already developed and commercially available for the purpose. Later on, as they gain more experience and develop greater confidence, we hope and expect that they will develop their own approaches to the discovery of some of the concepts.

We have already spent a year selecting and developing modules and means by which to illustrate and discover these concepts. Thus the instructors already have a range of resources available for this purpose.

Five groups of students with roughly five different interests and backgrounds will approach the same concept in an experimental/discovery exercise. They then spend the next two class periods, together with the appropriate homework time (a total of roughly 10 hours), working on the concept project. Their discovery observations are not expected to be sophisticated experiments, but rather relatively simple, straightforward experiments which clearly demonstrate the concepts in question. These are adults -- we do not intend for them to use experiments only appropriate for the K-6 age group! Although we are of course interested in improving their pedagogy, our major goal is to improve their awareness, interest, and performance in the scientific process and in science content.

Week:	Quarter One:	Quarter Two:
1	What is Science? Intro to Course Concept Examples	Scientific Process Extending the Senses Scientific Communications Audience Analysis
2	Student Interests and Conceptions The Scientific Process	Concept 4
3	Concept 1	Concept 4
4	Concept 1	Concept 5
5	Concept 2	Concept 5
6	Concept 2	Concept 6
7	Concept 3	Concept 6
8	Concept 3	Concept 7
9	Integration of 1-3	Concept 7
10	Extending the Senses	Integration of 1-7 Social Responsibility The Future

Table 1. Preliminary Outline for the two quarter Science Without Walls courses. Each two week Concept Unit will consist of at least 6 hours in class and lab:

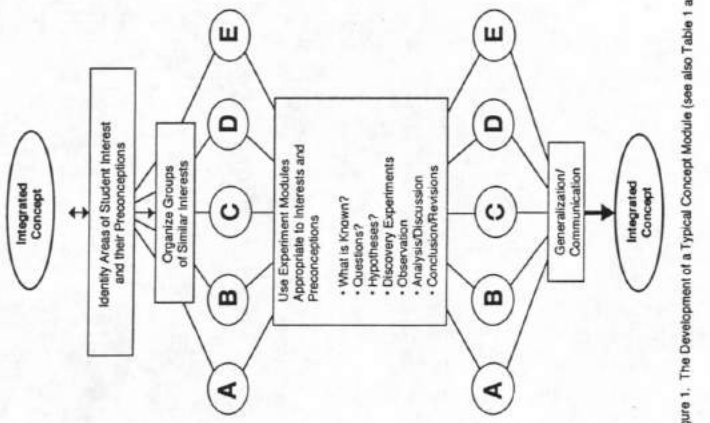

Figure 1. The Development of a Typical Concept Module (see also Table 1 and text).

TABLE 2

General Themes and Concepts in Science, Mathematics, and Technology

EVOLUTION & DIVERSITY: How does life change? Interdependence -- ecology -- ecosystems.

SYSTEMS: The Universe, the Earth, your little toe, a bacteria? What to focus on.

SCALE: Size, dimensions, measurement

STRUCTURE: What is matter? How are things organized? What is their function? What is their shape?

CONSTANCY: What is constant? How is it constant? Properties. "Constants".

CHANGE: What is changing? How much? How fast? Why? Forces. Variables?

ENERGY: What is it? Are there different kinds? How can we change it, use it?

DISORDER: How are things disorganized? Why are most things statistical? What is entropy?

PREDICTION: Models and theories -- experiments -- hypotheses -- the scientific process.

DECISIONS: What and who is right? wrong? How can complex decisions be made? Who makes decisions?

At the conclusion of this period they then come back to class, and each group gives a brief, 10-minute report. As they work through the course, and particularly into the second term, these reports will be expected to be increasingly polished and effective at communicating what they have discovered and learned. Not only will they be oral and written in nature, but they will also utilize posters and other visual aids.

The final class session for that topic will consist of a discussion among the class members of their conclusions and reports. Our goal and expectation is that they will "discover" that the same discoveries were made by five very different approaches, thereby emphasizing the integrated nature of the concept. They will also discover that they can approach a science subject from their own interests and background, and in that way begin to use their personal interests as tools and vehicles by which to extend their motivation and learning.

Finally, the instructor will further integrate their discoveries and experiences and extend them towards the next concept. As more and more concepts are developed, the students and the instructor will attempt to integrate the concepts among themselves, thereby developing a coherence and a firm foundation in science.

Table 2 lists ten general themes and concepts which we feel students should discover, understand, and appreciate. These concepts have been used by J. Andrade in a set of state-wide inservice courses titled "Integrated Science Concepts and Themes -- A Hands-on, Discovery-Based Inservice." They are based on three major reports:

1. F.J. Rutherford and A. Ahlgren, Science for All Americans (The Project 2061 Report), Oxford University Press, 1990.

2. National Center for Improving Science Education, Getting Started in Science: A Blueprint for Elementary School Science Education, Washington, DC 1989.

3. Loucks-Horsley, et al., eds., Elementary School Science for the 90's, The Network, Andover, MA, 1991.

In summary, we propose to develop and offer the 2-quarter "Science Without Walls" course -- a discovery-based approach to the key concepts and themes of science and technology. During the first year the course will be offered each quarter to 25 selected elementary education majors. In the second year the course will be expanded to all 100 elementary education majors. The course will then be a standard science sequence for elementary education majors and will be part of the regular course offering.

The project will be directed by J.D. Andrade. Joe and his colleagues, Julie Gess-Newsome and Sid Rudolph, will be responsible for the bulk of the course. T. Stoddart will help in the assessment of preconceptions and in pedagogical approaches.

We look forward to submitting a more detailed full proposal.

Background Information:

Dr. Joe Andrade is a Professor of Bioengineering, of Materials Science, and of Pharmaceutics at the University of Utah, and is the former Dean of the College of Engineering (1983-87). Several years ago Joe became increasingly interested in the issue of science education for the general population.

Joe is an accomplished scientist and engineer with 5 books, over 100 peer-reviewed papers, and 5 patents. His research group focuses on proteins at interfaces and proteins as engineering machines and devices.

In addition to these accomplishments as a scientist, Joe has recently decided to devote a significant portion of his time and career to the area of science education. He recently established the Center for Integrated Science Education at the University of Utah and is working to involve the faculty, staff, and graduate students on campus who have interests in science education. Joe is currently providing inservice programs for local school districts, chairs the Program Committee for the new Utah Science Center, and is active in enhancing science education throughout the area.

Joe's current activities in education are certainly not his first. While in graduate school Joe taught high school general science, biology, and chemistry in a parochial high school in Denver. It was from this teaching experience that Joe gained an appreciation for the power of teaching students science concepts based on themes which attracted their attention. Joe was also in a cooperative elementary program where he and his wife, a first grade teacher with 12 years of experience, worked together in developing experiential modules for elementary students based on the phenomenon of bioluminescence. His inservice courses, "Integrated Science Concepts and Themes," and "Science in the Dark! -- Bioluminescence-Based Science Discoveries" are very popular and well received.

Dr. Julie Gess-Newsome is an Assistant Professor of Science Education in the College of Education. As a science educator, her research focuses on the science understandings of preservice and inservice teachers at the elementary and secondary levels. Julie's interests in these topics have been stimulated by her eight years of experience as a high school biology and general science teacher. With this background, she was surprised at the poor quality of instruction in the science content courses which she completed as part of her Ph.D. studies. This experience raised questions concerning the understandings which students, particularly preservice teachers, derive as a result of college and university science courses. In particular, she is interested in the impact of university science courses on the conceptual understandings which teachers have of science, methods of enhancing those understandings, and the mediating variables which influence the translation of such science understandings to classroom practice. These research interests, at both the preservice and inservice level, have been explored in a number of research studies as well as in her dissertation. Julies is currently teaching the preservice elementary and secondary science methods course at the University of Utah, as well as science education courses at the Master's and Ph.D. level.

Dr. Sid Rudolph is an Associate Professor in the Department of Physics. Sid was initially hired to participate in the development and implementation of a program to deliver physics instruction by means of teleconference technology to students in remote areas of the state. In addition, Sid taught a number of lower division physics offerings and took on the task of revising the department's lower level laboratory courses. His current responsibilities are based in this early work: the design and implementation of a number of laboratory programs for the lower division students as well as the teaching of one or more of the major lower division physics sequences.

Sid has been involved influentially in the teaching of physics at both the college and public school levels. Sid has been both the President and a Section Representative for the American

Association of Physics Teachers, and has been instrumental in the formation of the Southern Wasatch Alliance for Physics, a loosely knit group of university, college and public school educators interested in improving physics education in particular, and science education in general in the Wasatch front schools.

Perhaps most important, Sid's enthusiasm for and dedication to the improvement of physics education has been demonstrated in the development of a number of externally funded (Eisenhower, formally Title) programs which assist secondary physical science teachers and elementary school teachers in improving their science teaching. These summer offerings, developed and taught by Sid and a team of local educators, have proven to be a great success. Utilizing the best available local talent and the resources of the University of Utah, such programs have positively influenced how science is taught in Utah's public schools.

Dr. Trish Stoddart is an Assistant Professor in the College of Education. Trish's area of expertise is the cognitive and developmental psychology with a focus on teacher learning and development and teacher education. She is particularly interested in the development of subject-specific pedagogy and has conducted research in the areas of mathematics and science. As a Senior Researcher with the National Center for Research on Teacher Education, she was involved in a five year study on teachers' subject matter knowledge. She brings to this project her expertise in the development of teachers' content and pedagogical understandings for teaching science. Over the past two years she has investigated the scientific conceptions of University of Utah elementary education students and the use of conceptual change pedagogy to improve their science content knowledge. This work will contribute to the development of this project. Trish has published extensively in the areas of teacher learning and development.