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A Preliminary Proposal to the
Instructional Materials Development Program
Elementary, Secondary, and Informal Education
Directorate for Education and Human Resources
National Science Foundation

From:
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Interest-Based Science: A *Personal* Sound and Music Laboratory

; eating against one's will is injurious to the health, so study without a liking for it
nory, and it retains nothing it takes in." This quote is attributed to Leonardo da
rticularly appropriate in modern K-12 science education, especially at the grade 5-

ne is interested in *some*thing -- this is the assumption behind the Science by
oach of the Center for Integrated Science Education (CISE) at the University of

pose to develop experimental science kits based on a topic of major interest to most
populations: music. An interest-based approach to science facilitates the
the student in topics and activities in which they are already interested and makes it
ıtforward to increase their interest spectrum. We will connect their music interests
nces, mathematics, and technology.
develop a Lableless Lab in Science and Music at the advanced jr. high and first year
el, incorporating the students' background in mathematics and life and physical
oal is to have them discover that there are very close relationships and interactions
and the sciences, and that they can build on their music interests and skills in
expanding their science and technology interests and skills.

2 Years.

Direct Cost	$110,000
Institution Match	$25,000

view the science content of current products and educational materials related to
, hobbies, and other activities and assess the potential of a music based science kit
terest in science and related professions among students who are initially
he sciences.
camine the role of music in science museums and centers by working through the
ciation for Museums and the Association of Science and Technology Centers.

3) To research and establish the available connections and extensions between music and the various sciences by identifying a set of appropriate books and models with which to demonstrate and expand these connections.

4) To develop a set of experimental music activities which amplify and unravel the connections and extensions between music and the sciences (Figure 1).

5) To develop a personal Lableless Lab in Science Through Music.

6) To test the Lableless Lab in Science Through Music in a limited high school population and in an adult night school population.

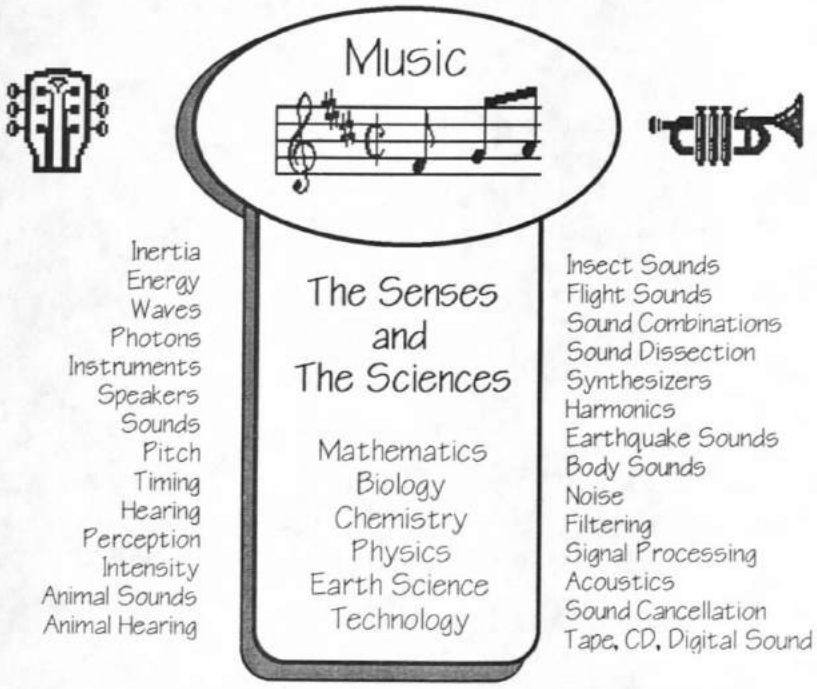

Figure 1: Diagram showing connections and topics relating music and science.

Significance:

Considerable concern has been expressed in the past decade about the growing disinterest in science studies and careers among high school students (1,2). Despite an increasing number of programs designed to interest students in the sciences, there has been little concerted effort to directly address the very populations which express considerable *disinterest* in the sciences.

Our Science by Seduction approach is based in large part on Gardner's *Theory of Multiple Intelligences* (3, 15). The approach accepts the fact that different segments of the population have different aptitudes and interests. Rather than ignoring or trying to change this, we have developed and built courses and workshops based on that very concept. (12,13).

There is a great deal of science in music and many famous scientists have been accomplished musicians. Leonardo da Vinci also provides an excellent example of an individual with incredible accomplishments and skills in the arts, the sciences, engineering and technology, and music (having invented and performed on his own unique musical instruments).

The so called right vs. left brain model, often employed to "explain" or rationalize the different interests and aptitudes of various individuals, is well analyzed by Shlain (4), who concluded in part that the true goal of education ought to be to show students how they can indeed synthesize and connect their right and left brain to achieve enhanced levels of creativity and productivity.

Shiela Tobias, in her important study, *They're Not Dumb -- They're Different* (14), showed that Arts and Humanities students are not necessarily disinterested in the sciences, but they are put off by common science presentation and teaching methods.

We propose to take students with interests and aptitudes in music and enhance and expand their interests to include science -- *not* as a substitute for their interest in music, but rather as an enhancement of that interest, and to *apply* their music skills, modes of thinking, and creativity *to the sciences*. We expect to produce groups of individuals with enhanced levels of creativity and perception (4). *Science for All Americans*, argues strongly and persuasively for an integrated approach to the sciences (1,2). It is also important that at least some subset of the population go beyond that report and consider an integrated approach to education in general (15).

Relevant Experience and Personnel:

The Principal Investigator, J. Andrade is Professor of Bioengineering and Co-Director of the Center for Integrated Science Education at the University of Utah. Joe has almost no musical skills and, up until five years ago, had little interest in the arts. Reputed by his wife to be completely tone deaf and incapable of dealing with primary colors, he still enjoys listening to music, and has occasionally made some limited, but futile, attempts at producing art. With the founding of the Center for Integrated Science Education in 1992, and the realization and adoption of Project 2061's goals and guidelines, Joe began to develop a set of courses and workshops designed initially for elementary teachers, called Integrated Science Concepts and Themes (12). As he developed these workshops, he realized the importance of inducing previously disinterested individuals to relate their own personal interests to the sciences. In working with elementary teachers in Utah Joe found that what really interests them are the things that they would rather be doing if they could be doing anything at all. Some of those topics include: gardening, cooking, outdoor activities, sports, dance, sex, music, and art, as well as many others. We have adopted one of those interests for this IMD proposal: *music*. We hope to address the other ones in future proposals and activities.

Orest Symko, Professor of Physics, is an expert on teaching science and technology through sound and music. He is recognized as one of the outstanding teachers on campus, and has taught a liberal education course, "The Physics of Hi-Fi," for the last 17 years. Together with Mr. Zigmund Peacock, Instructor/Demonstrator for the Department of Physics, they have put together an incredible array of demonstrations and experiments for this course, including a strong hands-on, vigorous laboratory component. Both Dr. Symko and Mr. Peacock will be part of the team involved in designing and implementing a Lableless Lab in Science Through Music.

Dr. Paul Wheeler, Professor of Electrical Engineering at Utah State University in Logan, Utah and an expert on acoustics, has been teaching courses on science through music for several years. He will serve as an advisor/consultant. Dr. Wheeler has almost single-handedly developed a small, hands-on interactive science museum in Logan, Utah, The Discovery Center, which is very well represented in sound and music activities.

Andrade, Symko, and Peacock have been involved in the design and development of interactive, hands-on exhibits for local museums in the Salt Lake City area, including the Leonardo Project, a major travling science center now in the advanced development phase, which will be traveling throughout the state of Utah during its centennial year, 1996.

In addition, we expect to involve Dr. R. Duncan Hines of the Department of Cognative Sciences, University of California, Irvine. Dr. Hines has also taught science through music and is the author of the recent book, *Sound and Hearing: A Conceptual Approach*. His interest is more in the area of the theoretical underpinnings of sound, music, and their connections to science, rather than in hands-on activities, and serves to complement and enhance the interests and skills of the Utah group.

Dr. Magdy Iskander, Professor of Electrical Engineering and the Director of the Center for Computer Applications in Engineering Education, will be involved in the part of the project related to the development of a CD containing the sound and audio components, which will be important and even critical to the Lableless Lab kit. Dr. Iskander's laboratory is fully equiped to produce CD ROMS.

Two project managers from CISE will be directly responsible for organizing and implementing the project. Mary McDonald, Manager of CISE, edits the *Explore!* newsletter and serves on the Program Planning Committee for Leonardo on Wheels, a local traveling science/arts center. She has participated both as a student and teaching assistant in science exhibit courses. Recently, CISE and the Utah Girl Scout Council were selected to be a National Science Partnership site to foster increased female participation in the sciences. As part of that project, Mary will involve the Girl Scouts in the development and presentation of innovative exhibit projects for Leonardo on Wheels. Her expertise is in science content development.

Rachel Gerson recently joined CISE. She has a Masters of Arts in Education from Stanford University with a specialization in curriculum development and teacher education. She has worked closely with Dr. Mike Atkin, professor at Stanford, in informal science education and programs for teacher outreach. Rachel has teaching experience on the Zuni Indian Reservation in New Mexico and the Keystone Science School in Colorado.

The Center for Integrated Science Education has embarked on a major effort to develop interest-based science courses for the university undergraduate population. Joe is now teaching a two quarter liberal arts course, Science Without Walls: Science for the Science Resistant, an interest-based approach. He also gives workshops regularly for elementary teachers which are based on the teacher's personal interests (12).

CISE consists of an Executive Committee representing each basic science department in the College of Science, the College of Engineering, the Graduate School of Education, and the College of Earth and Mineral Sciences, as well as the informal science education museum community. Joe Dickinson, Professor of Biology, serves as Co-Director of CISE. We have close coordination with other education and outreach activities throughout the campus.

CISE's Leonardo Laboratory, directed by Mr. James Biggs, will also be involved. This is a hands-on, projects-based laboratory in which the Centers workshops are held and which is fully equiped for the design, development, and proto-typing of interactive hands-on exhibits and activities, including the ultra-miniature versions of those which will become the Lableless Lab in Science Through Music.

Experimental Design and Methods (in order of Specific Aims):

Task 1) will be conducted largely through exhibits, shows, and workshops at the major science, arts, and music educational conferences, e.g., the National Science Teachers Association (NSTA), the National Music Educator's Association annual meetings. We will survey the existing music and science education communities with respect to their responsiveness and interest in interest-based science.

Task 2) will involve the staff and program committee of the Utah Science/Art Center Project, which is planning and building a major hand-on science/arts center in Salt Lake City. We will also involve other members of the Association for Science and Technology Centers (ASTC). There are

a number of museums which are starting to draw connections between the sciences and the arts, including the Exploratorium in San Francisco (8,16) and a new science center in Albuquerque, New Mexico. Other science centers with strong music exhibits and components include The Franklin Institute in Philadelphia, the Ontario Science Center in Toronto, and many others. Indeed, every major hands-on science center has a music, sound, and hearing component. It is important to note that the Lableless Lab in Science Through Music will not simply miniaturize and duplicate these existing activities and experiences, but rather will attempt to more effectively connect the observations and experiments to basic science concepts and understanding. In this task we will identify the museum/science center groups, make contact with them, and begin to involve them as advisors in this project.

Task 3) We will also work closely with the authors of books and materials who have developed such connections and who have developed science courses for non science students using an interest-based approach (5,8,23).

A very new "book" called *The Music Pack* (21) is an interactive, pop-up book which includes a 75 minute CD and a variety of hands-on activities. The goal is to teach music and musical appreciation, not science. *The Music Pack* serves as a very good example or guide as to what can be accomplished, however, in a small lableless lab format.

Another good example is the Klutz Press *Explorabook* (22), which can be found in almost any children's bookstore or science museum gift shop. Although the emphasis on this book is on optics and other topics, rather than sound and music, it serves as an excellent example of what is possible.

A local company, Protein Solutions, Inc. (PSI), is developing a set of Lableless Labs®. Their first one is Polymer Materials Science in which all of the materials, apparati, and information needed to discover all of the major concepts, principles, and laws of modern polymer materials science, is incorporated in a small, personal laboratory, designed to sell for about $50, together with a companion textbook. PSI has an interest in our personal lab in science and music and will provide input and advice upon request.

Task 4) We propose to magnify the science interests of disinterested students by fully developing a music-based approach to the sciences through creating music and science educational kits for hands-on learning.

There is absolutely no problem in connecting music to the physical sciences -- the physics of waves, sound generation, acoustics, sound transmission, the synthesis of sound, and its production are all popular and well developed topics (Figure 1).

The connection to the biological sciences will also be developed through the sense of hearing itself: the mechanism of hearing, hearing disorders, the threshold of pain or of hearing damage -- all are very popular topics, as well as the generation of sound by other members of the animal kingdom, the exquisite versatility of the human voice, the anatomy and physiology of the human vocal system, the repair of hearing defects, the diversity and beauty of bird calls, the entire sensory ecology and sensory physiology of the various species and their predators (5,6).

We will develop these connections by working our way through fundamental junior high and high school textbooks and using that which ties music, sound, and hearing to the disciplines of biology, chemistry, and physics.

Putting all of this into a kit is a bit more challenging. This will involve recording capability, sound and music analysis capability, and a number of simple tools and activities, including tuning forks, simple instruments, bird calls, etc. This will all be presented in the full proposal.

Evaluation, Assessment, and Dissemination:

The evaluation and assessment of this project will occur in three stages. First, the front-end evaluation will identify current classroom instruction and methods used to teach science. During the formative evaluation, the materials and activities developed will be prototyped and critiqued by the teachers and project staff. The summative stage will assess and document the overall effectiveness of the components of the project.

The CISE staff interacts with science educators from various organizations. CISE will discuss the experiences, progress and assessment of the project with those organizations. A summary report of the project will be available for distribution. Interactive workshops that demonstrate the project fundamentals will be presented at regional and national conferences. CISE presents at the National Science Teachers Association (NSTA) conferences, as well as selected professional science conferences.

Budget:

We anticipate a budget of $110,000 in direct costs over 2 years. The institution will provide a major salary match and other resources

Literature:

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