TexNET
Texas Network for Exhibit-based Learning and Teaching

TexNET partners the Fort Worth Museum of Science and History and the Exploratorium with three smaller science museums that have strong connections to rural and Spanish-speaking populations in Texas—Discovery Science Place, Laredo Children's Museum, and Science Spectrum. TexNET, a four-year project modeled on the Exploratorium Network for Exhibit-based Teaching (ExNET), of which Fort Worth is a lead member, builds on lessons learned from past exhibit outreach models and addresses the needs of small, rural partners for exhibits, teaching resources, and staff development.

TexNET pairs annually rotating exhibit sets with professional development and capacity-building workshops. Each small museum partner hosts each set of ten exhibits for one year. Exhibit topics are 1) motion, 2) weather, and 3) sound. Workshops focus on inquiry learning techniques, science content, program and workshop design, as well as the institutional needs of each partner.

Intellectual Merit
TexNET puts rich science resources and sophisticated inquiry approaches to teaching and learning into the hands of small science museums that work extensively with rural communities. It provides high quality-science exhibits and programs to traditionally underserved audiences. The network leverages the strengths of the small and large partners to build institutional capacity and their community presence.

Broader Impact
Partner museums will be stronger, more viable institutions with a staff re-energized by professional development. New visitor-centered interpretive strategies will impact partners' capacity to understand and meet community needs. To expand the network and reach new audiences, exhibit sets remain with the network at the end of the project. TexNET tests how informal science institutions can better support the efforts of smaller science centers and museums to create a stronger regional science education infrastructure.

TexNET
Texas Network for Exhibit-based Learning and Teaching

I. Statement of Need

National studies indicate a serious need for additional educational resources in rural communities. Although 49% of the nation's public schools, 41% of teachers, and nearly 40% of students are in rural and small towns, less than 25% of the national education budget makes its way to rural and small town schools. (National Education Association)

Texas ranks first nationally in size of rural population. A total of 3.6 million people live in rural areas (Rural School and Community Trust). Many students are affected by the disparity in educational spending. Minorities make up 35% of underserved rural students, almost twice the national average (Rural School and Community Trust).

The National Science Foundation (NSF) has recognized the acute need for improved science education resources in rural Texas by funding two large initiatives: the Texas Rural Systemic Initiative (TRSI) and the South Texas Rural Systemic Initiative (STRSI). Judy Kelley, Executive Director of Rural Systemic Initiatives emphasizes that, “a big challenge rural school districts face is isolation and limited access to information.” *Science Education Reform in Rural America: A Snapshot* by the Education Development Center (EDC), concurs, “The physical and geographical isolation of rural communities frequently means limited access of rural educators and students to science-rich organizations, technical assistance providers, and professional development organization.” The Rural Systemic Initiatives forge partnerships by working with community groups and by linking existing programs and resources.

Texas RSIs recognized the essential role of informal institutions in rural science education reform by forming the Texas Informal Science Education (ISE) Action Team in 1996. It brings together informal science educators in Texas—representing museums, zoos, aquariums, state parks, and nature centers—with formal educators, including teachers, school administrators, regional education service centers, university systems, and parent-family organizations. In *Texas Informal Science: Guidelines for Supporting the Improvement of Science, Mathematics, and Technology Education in Texas*, ISE outlines three organizational and programmatic areas that must be improved in informal institutions: Organizational Quality, Family Learning and Public Awareness, and Teacher Preparation and Professional Development. ISE emphasizes “fostering opportunities to strengthen and expand the leadership and capacity of emerging informal science education networks within the state . . . and encouraging participation of Texas organizations in informal science education activities at national and local levels to increase knowledge and awareness of effective models.” (Charles A. Dana Center)

Content- and experience-rich science museums (as well as zoos, natural history museums, aquariums, children's museums, and art museums) are uniquely positioned to support educational infrastructure because of strong connections to communities. Because they are places “where attendance is voluntary and meaning not prescribed,” (Hein and Alexander) visitors are comfortable and free to learn in a nonjudgmental environment. Informal centers are demonstrative and experiential rather than didactic, and perceived to provide reliable information. They have visitors' trust, which forms a strong basis for learning (Busquin).

Despite their ideal position to impact education, many smaller informal science centers and museums do not have sufficient resources or support to improve the organizational and program areas outlined by ISE. In 2003, the Fort Worth Museum of Science and History hosted a meeting of three small science museums from rural areas of Texas: Discovery Science Place (Tyler), Science Spectrum (Lubbock), and Laredo Children's Museum. Each museum expressed needs specific to its audiences, resources, and location. For example, Discovery Science Place is outfitted with a state-of-the-art Webcast studio courtesy of SuperNET, a program of the Texas Rural Systemic Initiative, but lacks the expertise to use it. The Science Spectrum is struggling to respond to growing demand for programming and resources for families that home school their children. The Laredo Children's Museum needs exhibit renewal, and stronger science content, to encourage teachers to make repeat visits.

All three museums act as a resource for numerous audiences in their regions (teachers, students, families, English-language learners, etc.). However, the lack of ongoing support in exhibits and professional development makes it difficult to offer audiences new and varied programming. Although they have community buy-in, they are not able to meet the extraordinary demands on their limited resources.

Museums and science centers have tested a number of exhibit outreach models aimed at underserved audiences, all with varying amounts and types of exhibits, teaching materials, access to educational staff, and logistical support. TexNET will draw on successes and the lessons learned to build a model suited to smaller museums in Texas. Notable examples include the Science Carnival at the Pacific Science Center (NSF 88-50609) and the National Science Outreach Network at the Oregon Museum of Science & Industry (OMSI) (NSF 90-53623). The Science Carnival focused specifically on programs for school groups. TexNET will draw on this model for formal education programming ideas but will more closely emulate the OMSI program by working in informal educational settings. TexNET will build on the lessons learned from the National Science Outreach Network by actively addressing exhibit maintenance issues and by selecting exhibits based upon durability. Programs in Australia and New Zealand, which are similar to the Science Carnival, aggressively address the science education needs of the large rural populations in both countries. Science on the Move from Questacon (Australia) and the Science Roadshow in New Zealand successfully deal with issues of culture and language through exhibits and programs. TexNET will draw on both models, and in particular on Questacon's expansion of Science on the Move into the Pacific. Working with small isolated communities in the Pacific Islands, Questacon staff worked with local educators, creating on-site exhibit labels to localize exhibits, cross language barriers, and provide culturally appropriate references.

II. Background

Since 1998, Fort Worth has been a member of the Exploratorium Network for Exhibit-based Teaching (ExNET). ExNET is a hybrid exhibit and teaching program that annually rotates sets of 30-40 Exploratorium exhibits and professional development to nine mid-sized museums and science centers in the US and Mexico. ExNET helps partner institutions become leaders in their regional science education landscape. TexNET is based upon the ExNET model, and will draw upon the knowledge, experience, exhibits, and programs of the partnership.

Through ExNET, Fort Worth has expanded and improved its offering of interactive science exhibits, built on strengths in science and created a presence in physical science and mathematics, and solidified its position as a regional leader in teacher training and professional development. Specifically, Fort Worth has

- Increased exhibit attendance
- Developed new public programs
- Developed and participate in new grant projects
- Played a leadership role in a national network of like-mined informal science organizations
- Provided training to other informal science museums
- Solidified teacher professional development programs

Fort Worth receives 15 days per year of consultation with key Exploratorium staff during the six year term of the partnership agreement. Initially, consultation was professional development focused on the use of, the science behind, and the tabletop activities around ExNET exhibits. In the past few years, collaborative consulting has evolved into exhibit development workshops, inquiry institutes, site-based teacher development workshops for local school districts, and new program development around physical science and digital technology.

Fort Worth has taken an increasingly influential role in ExNET by providing resources and guidance to other participants in the network. For example, in 2003, Chip Lindsey, Director of Visitor Programs, assisted Museo Sol del Niño with planning and design as part of a project to rebuild an early childhood learning area. Fort Worth's developing relationship with Museo Sol del Niño, located in Mexicali, Mexico close the US border, will inform the development of TexNET materials for Spanish speakers and English-language learners.

TexNET will build on other Fort Worth partnerships as well. In 1999, Fort Worth partnered with the Charles A. Dana Center at the University of Texas – Austin, home of the Texas Statewide Systemic Initiative, and the Exploratorium's Institute for Inquiry (NSF 99-11834) to conduct formative work on a statewide inquiry network. In 2000, the Texas Center for Inquiry (TCI) was established as a partnership between the museum, Dana Center, and the Exploratorium. In 2001, the museum offered its first two-day workshop for 22 informal science educators from Texas.

Formative evaluation of a TCI two-day workshop offered to district leaders in 2001 indicated that "the Introduction to Inquiry Institute was quite successful….Many of the necessary elements are in place. The number of effective strategies used in this initial offering was very promising, and they provide fertile ground on which to grow the next offering." A report from the museum's first five-day Professional Development Design workshop offered in 2001 stated, "providing participants with personal, concrete experiences of inquiry and creating a vision of the need for and possibility of inquiry teaching in classrooms were the major strengths of the seminar."

III. Project Goals and Outcomes

TexNET will reach 2.25 million people over three years through annually rotating hands-on exhibit sets and related science programming and outreach.

Project goals

- Provide rich science learning opportunities for rural and underserved communities
- Develop the capacity of informal education staff at small science museums to design science inquiry learning experiences for visitors and educators.

- Build a robust network of informal science institutions that play an integral role in the local science education infrastructure.
- Test a model for providing rural audiences access to high-quality traveling exhibits

Project outcomes will be evident at each level of the network.

Rural and Underserved Audiences

- Access to high-quality science exhibits with bilingual graphics renewed annually
- New opportunities for inquiry-based science learning through dynamic exhibits and related public programs (camp ins, floor demonstrations, etc.)
- Opportunities for family science learning through improved floor staff facilitation, family science programs, and outreach
- Increased opportunity for students to acquire and practice TEKS (Texas Essential Knowledge and Skills) related to inquiry in science learning
- TEKS and TAKS (Texas Assessment of Knowledge and Skills) resources for teachers, including exhibits and related materials linked to TEKS
- Heightened public awareness of exhibitions and programs at local science museum through improved and expanded marketing

Small Science Museum Partners

- Hands-on exhibitions that include portable exhibits for outreach programs
- Staff development in science content and inquiry learning techniques that can be applied to exhibitions and programs throughout each museum
- Resources for Spanish speakers and English-language learners—bilingual exhibit graphics, ancillary materials, and both culturally and linguistically appropriate programs
- Exhibit renewal plus marketing materials and strategies for new and existing audiences
- Access to support and resources of larger informal institutions, specifically Fort Worth, the Exploratorium, and other ExNET partners
- Participation in a national network of informal science institutions through ExNET
- Increased capacity to support local students and teachers with exhibits and materials related to state science education standards
- Improved relationships with museum boards

TexNET

- Construction of three sets of 11 portable exhibits on Motion, Weather, and Sound and Music.
- Development of strong relationships between Fort Worth and Discovery Science Place, Laredo Children's Museum, and Science Spectrum with Fort Worth serving as a mentor and hub for science content expertise and resources
- Documentation and evaluation of a model for local and rural science education efforts

Fort Worth

- Staff development in workshop design and facilitation
- Increased capacity to support regional informal institutions
- Additional experience working with traditionally underserved groups of Texas
- Build and lead a regional network
- Regional leadership role in informal science education

IV. Project Outline

Fort Worth will contract with the Exploratorium to build three exhibit sets for annual rotation among partners. Fort Worth and the Exploratorium will provide maintenance, logistics, and marketing resources.

In year 1, all partners will participate in capacity-building and staff development workshops. The Exploratorium begins building exhibit sets. Evaluators lay groundwork for measuring the success of program goals. Fort Worth and the Exploratorium begin consulting with staff from the Discovery Science Place, Laredo Children's Museum, and Science Spectrum, starting with a series of TexNET institutes.

At the end of year 1, Fort Worth will host all three exhibit sets for three months in its temporary exhibition space. Staff from the three partners will attend a kick-off exhibit-based training workshop in Fort Worth to become familiar with the exhibits sets.

Starting in year 2, exhibit sets will begin annual rotation. Every installation will be accompanied by exhibit-based training led by Fort Worth with support from the Exploratorium. Workshops will focus on the science behind and demonstrations built around exhibits, and will move to programming for specific audiences (visitors, teachers, students). Capacity-Building Workshops, starting year 2, will address audience cultivation, museum profile building, and staff development. Evaluation will occur throughout.

V. TexNET Work Plan

Year 1

- Initial advisory meeting and TexNET partner meeting in Fort Worth, attended by three representatives from each partner (month 1)
- Fabrication of exhibit sets at the Exploratorium (month 1)
- Compiling of teaching resources and development of Web resource (month 1)
- Institute 1 at Exploratorium attended by 3 representatives of each partner (month 3)
- Institute 2 at Fort Worth attended by 3 representatives from each partner (month 6)
- Exhibit sets shipped and installed at Fort Worth by Exploratorium staff (month 9)
- Exhibit-based training workshop held at Fort Worth. Co-led by Fort Worth and Exploratorium staff. Attended by three staff from each small museum (month 10)
- Exhibit sets shipped and installed by Fort Worth and Exploratorium (month 12)

Year 2

- Three educators (two from Fort Worth, one from the Exploratorium) conduct exhibit-based training workshops at each small museum. (month 13)
- Institute 3 at Science Spectrum. Attended by 3 staff from all partners (month 14)
- Fort Worth and Exploratorium maintenance staff (one from each museum) conduct on-site routine exhibit maintenance and inspection (month 15)
- First set of Specialized Capacity-Building Workshops facilitated by Fort Worth and Exploratorium (month 18)
- Institute 4 at Laredo Children's Museum for 3 staff from all partners (month 19)
- The 5th, and final, Institute at Discovery Science Place attended by 3 staff from each partner (month 23)
- Fort Worth staff de-install and install exhibits at each museum partner (month 24)
- Evaluation of ideal conditions for sustainability.

Year 3

- Fort Worth educators lead exhibit-based workshop at each museum (month 25)
- Fort Worth exhibit maintenance staff (two) conduct routine exhibit maintenance and inspection at each partner site (month 27)
- Second set of Specialized Capacity Building Workshops held at three small museums. Facilitated by Fort Worth and Exploratorium staff (month 30)
- Fort Worth staff de-install and install exhibits at each museum partner (month 36)
- Planning for post year 4 sustainability.

Year 4

- Two educators from Fort Worth conduct exhibit-based training workshops at each small museum partner (month 37)
- Fort Worth staff (two) conduct exhibit maintenance and inspection (month 39)
- Third, and final, set of Specialized Capacity Building Workshops at the three local museums. Facilitated by a Fort Worth and Exploratorium staff (month 42)
- TexNET program moves into post-NSF funding phase (month 48)

VI. TexNET Partners

The program links the regional leadership and strong staff capabilities of the Fort Worth Museum of Science and History, the knowledge of and connection to rural audiences of the Discovery Science Place, Laredo Children's Museum, and Science Spectrum, and the exhibits and professional development experience of the Exploratorium. Each partner brings unique abilities to the network and will serve and benefit in different ways.

A. TexNET Hub—Fort Worth Museum of Science and History

Fort Worth will be the leadership, educational, and administrative nexus of TexNET, coordinating exhibit rotation and maintenance, facilitating workshops, and providing educational materials. Established in 1941 as the Fort Worth Children's Museum, the mission of the Fort Worth Museum of Science and History is to increase public understanding and appreciation of science and the human experience through interaction with exhibits, programs and the museum collection. Permanent exhibits include *Lone Star Dinosaurs*, *Hands-On Science*, *ExploraZone*, *KIDSPACE*, *DinoDig*, and *Coming through Cowtown.* The museum has two galleries that host 5-6 exhibitions a year, an Omni Theater, and a planetarium. Programs include Museum School, Museum Preschool, Family Science Nights, Hands-On Science Partnership, community events, and teacher professional development. The museum welcomes over 1 million visitors annually, making it the most popular cultural attraction in North Texas. Fort Worth is a leader in the Texas Informal Science Education Association.

The museum has collaborated with school systems and universities throughout the state to create programs supporting state educational standards and life-long learning. The museum is a founding member of the Science Museum Exhibits Collaborative, a member of the Youth Museum Exhibit Collaborative, a member of the NSF sponsored PIE – Playful Inventive Exploration project led be MIT, and a partner in the Exploratorium Network for Exhibit-based Teaching (ExNET). The museum is active in two NSF National Centers for Teaching and Learning—the Texas A&M Center for Applications of Information Technology in the Teaching and Learning of Science (NSF 00 83336), and the Center for Informal Learning and Schools (NSF 01 19787), a partnership of the Exploratorium, Kings College, and UC Santa Cruz.

TexNET partners will receive preferential admission to the Texas Center for Inquiry, the Exploratorium's Institute for Inquiry, and the Center for Informal Learning and Schools.

The TexNET model is based on Fort Worth's participation in ExNET and also draws on its experience with two traveling exhibitions: *WHODUNIT? The Science of Solving Crime* (NSF ESI 9253370) and *Lone Star Dinosaurs*. Since 1993, *WHODUNIT?* has traveled to 30 venues and was cited as one of the best traveling exhibitions at a recent NSF-sponsored conference on *Best Practices in Exhibition Design*. *Lone Star Dinosaurs* is a 2,200 sq ft exhibition that traveled to smaller venues, such as libraries, community centers, and schools throughout Texas, 1995-97. Both exhibitions gave Fort Worth experience in logistics and maintenance of traveling exhibits.

B. TexNET Local Science Center Partners - Discovery Science Place, Laredo Children's Museum, and Science Spectrum

The TexNET museum partners are well established and serve large areas (Appendix B). Although challenged for resources, these museums have committed staff, well-developed programs, and buy-in from their communities. They are poised to deliver science content and programs to hard-to-reach audiences, including those in rural areas.

<u>Discovery Science Place, Tyler, Texas</u>
"There are lots of opportunities and challenges because we have a whole population of children that have never done anything in science besides read the chapter and answer the questions. The area of hands-on is wide open." —Katie Powell, Executive Director, Discovery Science Place

With 80,000 of the county's 171,000 residents, Tyler is the largest city in east Texas. Nearly 60,000 people, half of them students, from 32 surrounding counties, visited Discovery Science Place (DSP) in 2001. Of the Tyler school district's 16,626 students, 53% are economically disadvantaged. The students are 36% African American, 27% Hispanic, and 36% Caucasian.

The Science Place is a hands-on science museum founded in 1993. DSP has two exhibit halls. Programs include group tours, camp-ins, discovery Saturdays, STARLAB, Toddler Time, Girls at the Center, Family Free Days, Light & Color, the Power of Air, and birthday parties. DSP is scheduled to collaborate with Tyler Independent School District at teacher professional development workshops at Fort Worth's Texas Center for Inquiry in summer 2003.

Discovery Science Place is well established in its community and has the largest budget and staff of the three TexNET local partners. However, the museum is looking to renew its collections and develop resources. DSP is concerned with providing teachers and school groups with resources addressing the new Texas Assessment of Knowledge and Skills exams. Only 15% of these exams are devoted to content while 85% focuses on Texas Essential Knowledge and Skills (TEKS). TAKS standards require students of all ages to ask questions and think critically about scientific phenomena.

DSP Director Katie Powell is concerned that students in the Tyler school district are unprepared for such standards. DSP plans to use TexNET exhibits, which have strong ties to TEKS (Appendix F), to improve existing programs for students and develop new ones. For example, TexNET workshops at DSP will emphasize teaching concepts related to TEKS from the exhibits through demonstrations, tabletop activities, and pathways for teachers and students.

Specialized capacity-building workshops at DSP will respond to specific needs.

- Webcasting Workshop—DSP has a new Webcast studio and T1 line, but staff are looking for assistance to take advantage of the potential for either in-house programs or distance learning. The Exploratorium pioneered Webcasts for science education and will provide technology and techniques for programs such as student-produced Webcasts.
- Outreach Program Development—Current outreach topics overlap with the themes of the TexNET exhibit set on motion. Fort Worth will introduce table-top activities, demonstrations, and other education materials to augment current programs.

DSP has strengths in marketing and development, areas in which the other TexNET partners struggle. Its board recently worked with a fundraising consultant, and as a result, responsibility to fund programs and operations and has been further shifted from staff to board. This experience will contribute to the "Profile Building" Institute and will be a strong example for the other partners.

<u>Laredo Children's Museum, Laredo, Texas</u>
"There are children who visit us from small pueblos in Mexico without schools. Their parents might not read or write in Spanish or English and have trouble supporting their kids' education."
—Evelyn Smietana, Executive Director, Laredo Children's Museum

Laredo Children's Museum (LCM), founded in 1991 on the Texas/Mexico border, serves one of the most disadvantaged communities in Texas. The population of the metropolitan area is 201,292, and Nuevo Laredo, immediately across the border, is home to roughly 500,000. Of the school district's 22,547 students, 99% are Hispanic and 91% economically disadvantaged. Fifty-eight percent are enrolled in bilingual and/or ESL programs. The museum is a resource for families, educators, and volunteers, reaching 182,435 people last year through bi-lingual science exhibits, workshops, summer camps, school programs, and outreach. The museum frequently works in Las Colonias—densely populated, low-income communities along the border.

LCM has an annual budget $250,000 with 3 full-time, and 13 part-time staff. Services range from childcare while parents shop at LCM's location in the Mall del Norte to workshops on Mexican holidays that bring together both English and Spanish speakers. LCM's role as a gathering place has earned it the trust of the community but stretched its resources and limited its ability to address science topics, including inquiry.

TexNET will provide LCM with quality interactive science exhibits it has been unable to afford. Exhibit-based workshops will focus on infusing museum programs with science content, such as hands-on science for students in LCM's after-school tutoring program. Many parents are not comfortable helping their children with schoolwork due to barriers of language or limited education, making the tutoring program a valuable resource.

LCM will benefit from and contribute to workshops on Spanish speakers and Hispanic audiences. Workshops will tackle co-development of culturally and linguistically appropriate bi-lingual text for LCM's on-site audience and for outreach at Las Colonias. Fort Worth will work with LCM to develop a Family Science Night and create stronger relationships with schools. The portability of some exhibits will allow Laredo, Fort Worth, and Exploratorium staff to reach Las Colonias—an important, growing audience that is not likely to visit museums.

Science Spectrum, Lubbock, Texas
"We are the only science museum in a 200-mile radius. The Fort Worth Museum is the only support for our organization in the state." —Sandy Henry, Executive Director, Science Spectrum

Lubbock is a city of 197,117 in northwestern Texas. The Lubbock School District has 29,026 students, 15% African American, 43% Hispanic, and 41% Caucasian. Fifty-four percent come from economically disadvantaged households. Annual attendance at Spectrum is 250,000 students (from over 60 districts), teachers, families, tourists, and outreach audience members from West Texas South Plains and Eastern New Mexico.

The Spectrum, opened in 1989, features over 200 interactive exhibits, an OMNIMAX®, live animals, live demonstrations, an area for young children, funshops, and traveling exhibitions. Outreach programs extend 200 miles from Lubbock, serving 12,000 youth annually. Spectrum is the hub for the Texas Region 17 educational service unit and is the distribution center for curriculum materials, including FOSS kits. The museum offers professional development, some necessary for Head Start certification.

Science Spectrum was a participant in the Exploratorium Starter Sets project in 1993 (NSF 92-53404). It provided new science centers with interactive Exploratorium exhibits. Starter Sets did not include consulting and did not offer participants resources to encourage visitor interaction with exhibits. Over the past six years, the Exploratorium has incorporated lessons learned into ExNET, addressing both consulting and maintenance.

C. TexNET Exhibits/Consulting Partner—The Exploratorium

The Exploratorium is a museum of science, art, and human. It receives 525,000 visitors annually, including 120,000 students and teachers on field trips. Its award-winning Web site receives 17 million unique visits a year and offers over 12,000 pages of online activities, exhibits, and educational resources (www.exploratorium.edu). Over 7 million people see Exploratorium exhibits at science centers around the world. The Exploratorium's mission is to create a culture of learning through innovative environments, programs, and tools that help people nurture their curiosity about the world around them. The Exploratorium pursues this mission through:

- A permanent collection of over 600 exhibits, including human perception (such as vision, hearing, learning and cognition), life sciences, and physical phenomenon (such as light, motion, electricity, waves and resonance, and weather)
- Public programs, such as demonstrations, film series, Webcasts, lectures, and plays
- Professional development and research through the Teacher Institute (TI) for middle and high school math and science teachers, the Institute for Inquiry (IFI) for elementary science educators, and the Center for Informal Learning and Schools (CILS). TI and IFI offer workshops, online resources, publications, and an intellectual community of educators. CILS offers doctoral, post-doctoral, and professional development programs for educators, scientists, and researchers in the natural and social sciences. TexNET members will have preferential access to TI, IFI, and CILS programs.
- More than 30 titles for the public and educators, such as *Square Wheels*, activities for teachers with small versions of exhibits, and *Math Explorer* for after-school programs.

Fort Worth contracts with the Exploratorium for the duration of the TexNET project. The Exploratorium provides (1) sets of interactive science exhibits and educational resources, (2) workshop development and facilitation, and (3) access to the members and benefits of the existing ExNET partnership.

VII. TexNET Tools for Capacity Building—Exhibits and Workshops

A. Exhibits

In year 1, in cooperation with TexNET partners, the Exploratorium will build three exhibit collections on the topics of Motion, Weather, and Sound (Appendix C). Exhibits will be tied to Texas Essential Knowledge and Skills (TEKS) requirements (Appendix F). Exhibits will inspire play, encourage contemplation, and support a range of mediated programming. As a themed set, exhibits will create a welcoming, playful environment, a base for programming, a catalyst for community building, and an opportunity for increasing attendance and funding.

For example, the motion collection will be full of spinning, fluttering, and flying (Appendix D). As a looped, 30-foot rope squirts from a rotating platform, children jump through its slowly collapsing arches. A blue orb filled with a flowing blue and silver liquid spins intricate patterns. Visitors make stop-animation movies, splicing still frames and adding dialogue. In the center, the *Motion Theater* will be an iconic exhibit and multipurpose demonstration area.

Program support and curriculum-based material complement each exhibit set (Appendix E) and will be presented on the TexNET partner Website. Partners, empowered through workshop learning, will facilitate a high-level of engagement by linking teachers and parents with take-home activities and Web resources to encourage deeper exploration before and after the visit. Museum staff will encourage inquiry and informal learning by engaging visitors with questions, such as “What does this remind you of?,” and, “How did you do that?” Ideally, visitors will come to view TexNET partners as the first place to go for science resources, including a wide range of activities that link to TEKS. This will be important for teachers who must justify field trips and extra-curricular activities with clearly stated links to TEKS.

An example of the type of TexNET exhibits, *Balancing Ball* makes plastic fruit and two-liter bottles hover on an adjustable column of air. Redesigned to maximize visitor experimentation based on prototyping and research conducted through the APE – Active, Prolonged Engagement project (NSH 00 87844), *Balancing Ball* will be accompanied by assets such as affordable take home projects (Appendix G), an exhibit-based exploration workshop for floor staff, and curriculum and Web links to online support material (Appendix H). Visitors can make their own *Balancing Ball* with a soda straw and ping-pong ball and take it home. Teachers and students can use a hair-dryer version of *Balancing Ball* to float objects of their own design. Students can formulate hypotheses, select and use equipment, collect, analyze and interpret information, observe and measure, and communicate valid conclusions. These activities promote of the type of learning defined in TEKS.

TexNET exhibits are chosen primarily from successful prototypes developed and produced by the Exploratorium and also include compelling exhibits from other exhibit designers such as the Animation Workstation from Creative Machines and Rope Squirter from Clifford Wagner.

Nearly all of the TexNET exhibits are also a part of the ExNET collections, providing a strong connection from the local museums to Fort Worth. As shown over 6 years of experience through ExNET, the selected exhibits will withstand the rigors of high energy environments. Maintenance needs are low, but not trivial: Fort Worth staff will provide on-site service to augment partner capabilities.

TexNET exhibits will encourage conversation and social interaction. In addition, each exhibit will strive to provide multiple entry points to encourage self-authored behavior, free-form exploration, and careful observation. By putting the emphasis on visitor behavior as well as exhibit content, exhibits and exhibitions will serve as catalysts for discussions, activities, and explorations that extend beyond their topic areas.

B. Professional Development

Workshops will help museums develop staff and resources for programming and exhibits. Workshops are two days in consideration of the limited staffing of smaller museums and the great distances between partners. There are 3 types of workshops:

TexNET Partner Institutes—Each partner will host a themed, two-day institute on capacity building. Institutes will be facilitated by Fort Worth and Exploratorium staff and attended by two people from each museum. Institutes will provide time for partners to strategize on institutional development and science education. The first institute, “Approaches to Inquiry Learning” at the Exploratorium, will introduce inquiry learning techniques. “What Exhibition? Marketing to Your Community” at Fort Worth, will help partners brainstorm marketing for each exhibit set. “After the Install: Program and Workshop Design” will discuss characteristics of successful programs and workshops. (Just prior to the third institute, local museums will have received the exhibit sets and the group will brainstorm programs specific to the exhibits.) “The Bottom Line: Profile Building in the Community” will focus on marketing and development. Board members from each partner will attend and will be encouraged to understand more about their roles as fundraisers. “Opening the Doors: Partnering with Community-Based Organizations” will discuss benefits and challenges of working with community groups as well as models for collaboration.

Exhibit-based Teaching Workshops—Two-day workshops will occur at each local museum after exhibit sets arrive. Workshops will explore the science behind exhibits, accompanying educational materials, and related tabletop activities and demonstrations. Workshops will develop educators’ ability to use, and facilitate use of, exhibits to allow learners to develop science understanding through their own questions and inquiries. Staggered workshops will allow one person from each museum to attend workshops at partner and become familiar with exhibits before they arrive. In year one, workshops will be led by the Exploratorium; in year two, co-led by Fort Worth and the Exploratorium; and in years three and four, led by Fort Worth.

Specialized Capacity-building Workshops—Fort Worth will hold two-day workshops annually at each local museum. Workshop structure depends on the goals of each museum. For example, the Science Spectrum has identified sight-disabled visitors as a target audience. One of Spectrum’s workshops will develop a camp-in for visually impaired visitors based on the “Blind Café” held in German museums. Other workshops at Science Spectrum will concentrate on curriculum development with TexNET exhibits for home school groups and teachers, and using the TexNET Sound collection to create programming linked to “Pulse,” an IMAX offering.

Workshops at Discovery Science Place will focus on after-school programming related to TEKS, outreach programs, and development of museum technology resources. The Laredo Children's Museum's workshops will focus on outreach activities to Las Colonias, exhibit label design workshops for Spanish speakers and English-language learners, and development of a Family Science Night with local schools, all identified as areas of need in initial planning meetings.

C. Marketing

Marketing materials will ensure that the impact of exhibits and staff development reaches museum audiences. TexNET partners do not have resources to develop marketing materials to attract new and repeat visitors. However, they do have well-established avenues for reaching their audiences and are knowledgeable about how to reach specific groups. All three local museums rely on membership mailings, print and radio ads, postcards, and school fliers. At the second institute, partners will create customized marketing campaigns. Following the institute, pamphlets, fliers, postcards, newspaper ads, public service announcements, etc., will be available to partners online in English and Spanish. Laredo will play a key role in developing bilingual materials. Lessons learned via ExNET will helpful: the Fresno Metropolitan Museum, located in an agricultural region of California very similar to Lubbock, receives significant amounts of free advertising by providing layouts to local newspapers in all standard sizes, just in case paying advertisers drop out at the last minute.

VIII. Evaluation and Research

Inverness Research Associates (IRA) will conduct a multifaceted evaluation of relationships between constituents, exhibits, and the network as a whole. Using a "logic model", they will identify the project's theory of action and study critical components. They will be a "critical friend" to the network, raising issues as museums work together, and providing feedback on realities of the field through their work with partner staff and community members served by museums. Evaluation will focus on tools of the network (professional development and exhibits). IRA will also assess network design and sustainability.

Background

IRA has evaluated many projects with components similar to TexNET. These include science education in rural communities (through NSF's Rural Systemic Initiatives), informal science education to underserved communities (including NSF's Community Science Workshop), and exhibit development with a collaborative component (TEAMS, Starter Sets, and Exhibit Resource Collaborative). They have also studied traveling exhibits to nontraditional venues (OMSI's National Science Outreach Network). IRA evaluated the Texas Eisenhower program and the initial Texas Institute for Inquiry.

Purposes of Evaluation

1) <u>Study and document activities and effectiveness of the TexNET model</u>. IRA will look at the resources each partner contributes, and how the network develops an infrastructure for building capacity to improve rural education.
2) <u>Evaluate the specific exhibits, education materials, and professional development offerings</u>. Keeping the overall goal of reaching rural underserved communities in mind, IRA will evaluate how exhibits attract new audiences, ways small exhibits are used in outreach, and how the infrastructure supports science education to the communities.

3) Conduct and publish research on the interaction of this exhibit-focused educational initiative within the rural education context. The TexNET evaluation will complement other projects in rural communities. IRA is studying Appalachia (through the AMSP, ACCLAIM, and ARSI projects) and helping document ways in which capacity of rural communities to sustain their own educational improvement can be enhanced.

IRA will document activities and overall effectiveness of the network. They will examine how staff from the five museums work together; the extent to which and ways in which participating in the network influences museums and staff; and overall lessons learned. (Note that IRA is conducting research through a supplemental grant on the collaborative processes of TEAMS 2.) Evaluation will help the network reflect on its work and identify key features of the model, which will inform how to adjust for continued sustainability beyond year 4.

Evaluation Work Plan

Study and document the activities and effectiveness of the TexNET model

Planning meetings: To understand the needs and interests of each partner, IRA will participate in key planning meetings. They will be experienced "outside eyes."

Staff interviews: Throughout the project, IRA will interview primary project staff from Fort Worth and the Exploratorium. Interviews will document the ongoing background thinking and framework of design choices. By making explicit assumptions, goals, and design choices, IRA will lay out features of the network, as well as strengths and issues, from the trainers' and exhibit builders' points of view.

IRA will interview staff at the Discovery Science Place, Science Spectrum, and Laredo Children's Museum. They will document staff needs and goals for involvement, ways they work with Fort Worth and the Exploratorium, and benefits of the partnership.

Evaluate exhibits, education materials, and professional development offerings

Exhibit evaluation: At key points in the project, IRA will look at how exhibits sets support project goals. IRA will assess how exhibits are customized for the rural context of TexNET. They will also focus on the degree to which Fort Worth and the Exploratorium are able to use exhibits to demonstrate science inquiry teaching, and the degree to which smaller museums are able to translate this to serve local rural audiences.

Evaluation of professional development offerings: IRA will observe workshops, institutes, and trainings. They will examine the roles of various players in trainings, and the nature of the science and pedagogy covered. They will also study ways that Fort Worth serves as a "hub" for the partner museums, the Exploratorium's role in these relationships, and how trainings incorporate methods and content that are culturally appropriate and sensitive to teachers, students, and other community members.

Conduct and publish research on the interaction of this initiative and the rural context.
Inverness will study at least two communities in detail and author cases from the community perspective that will document how community members interact with exhibits and programs, and the ways this initiative builds local capacity.

Research will also look broadly at the interaction of teachers, students, parents, and community leaders with exhibits and programming. It will document how this augments local museum staff, and how augmentation contributes to capacity for further work in the community. IRA plans to publish findings (in *Rural Educator: Journal for Rural and Small Schools* and *Curator* for example), to post the findings on the Rural Clearinghouse for Lifelong Education and Development server, and on the IRA Web site.

IX. Sustainability

A primary goal of TexNET is to create a sustainable model, in Texas and beyond, for reaching underserved communities with high-quality exhibits and programming. It is easy to imagine expansion of the network and recruiting other partners. In fact, other ExNET partners have expressed interest in participating in later phases and in creating similar networks in their respective regions.

Aligning TexNET and ExNET makes economic sense for sustainable growth. ExNET partners already use the network to attract funding, expand programs, and reach new audiences. ExNET is self-sustaining, with no direct government funding. Many partners leverage their participation to raise funds above program costs. Success of TexNET will highlight the benefits of regional networks, and new (and renewing) ExNET partners may pay an incremental increase to use TexNET exhibits and training to support creation of other regional networks.

Without direct sponsorship, it will also be necessary for partners to pay an annual fee to the hub museum, as is the case with ExNET. A preliminary analysis indicates that fees of $50,000 a year would support both the building of new exhibit sets and ongoing training. Issues such as investment by the lead partners, sponsorship, ideal network size, and affordability need to be studied further. The fourth TexNET Partner Institute will address development and fundraising and define strategies for sustaining ExNET.

X. Project Leadership

Charlie Walter of the Fort Worth Museum of Science and History will lead TexNET. Walter is Interim Director with administrative responsibility for the education, collections, exhibits, visitor programs, school services, and evaluation as well as the Noble Planetarium and OmniMax. Key Fort Worth staff include Colleen Blair, Director of School Services and Evaluation, Robert “Chip” Lindsey, Director of Visitor Programs, and Amanda Morales, Assistant Director of Visitor Programs.

Directors of Discovery Science Place, Laredo Children's Museum, and Science Spectrum will serve as Senior Personnel: Katie Powell, Sandy Henry, and Evelyn Smietano.

Joe Hastings, Director for the Center for Museum Partnerships at the Exploratorium, will guide exhibit production and capacity-building. Key Exploratorium staff include Ken Finn, ExNET Educator, and Shawn Lani, Senior Exhibit Developer. Subcontractor Kurt Gabrielson, founder of the Watsonville Taller de Ciencias Science Workshops, will contribute experience in workshop design for Spanish speakers.

XI. Advisors

Advisors will meet at the beginning of the project and at several meetings at annual ASTC conferences. They will be called on periodically for input. Advisors were chosen for specific expertise in aspects of informal learning and to bring a broad perspective.

Dr. Sally Duensing received the 1993 Museum Educator Award from AAM and directs the Center for Informal Learning and Schools project for UC, Santa Cruz. She held the Collier Chair in Public Understanding of Science at the University of Bristol, UK.

Ben Fleskes is Director of Design and Production at the Oregon Museum of Science and Industry. OMSI manages the largest traveling exhibit program of any national science museum, circulating more than 25 exhibits throughout North America and Europe.

Ian Kennedy directs Science–Technology Roadshow Trust. Since 1989, Roadshow teams have taken quality science exhibits and educational programs to children and schools throughout New Zealand, a country with a predominantly rural population.

Ana Lilia Martinez is Director of Education at Museo Sol del Niño in Mexicali, Mexico. Museo Sol del Niño has been an ExNET partner since 2002.

Dr. Ronen Mir directs SciTech in Aurora, Illinois. SciTech is the hub for the Midwest Wild Weather Project, a collaboration of the WEATHER PACC Museum Consortium, an NSF-funded confederation of nine museums disseminating exhibits and programs.

Norma J. Neely is Associate Director of Regional Projects for the Texas Rural Systemic Initiative, an NSF-funded project that works with school districts to improve the mathematics and science performance of rural students in Texas.

Paul Orselli is Director of Paul Orselli Workshop (POW!), an exhibit and workshop design firm. He was Director of Exhibits at the Long Island Children's Museum and is the author of *Cheapbook: A Compendium of Inexpensive Exhibit Ideas*, an ASTC publication.

Sarita Rodriguez oversees development and implementation of educational programs for diverse statewide audiences of the Bob Bullock Texas State History Museum.

Bonnie Sachatello-Sawyer directs Native Waters, an NSF-funded tribal water education initiative with traveling exhibits, a film, community leadership institutes, and young leaders camps.

Gillian Thomas is Director of the Miami Museum of Science. She was the founding director of Explore@Bristol. Ms. Thomas led a Wellcome Trust-funded network providing a model of sustainability for young Science and Discovery Centers in the UK.

Dr. Julie Thomas is a professor of Elementary Science Education at Texas Tech University. Thomas is the author of numerous articles on elementary science education and has participated in 11 funded projects since 1996, including the *Preservice Elementary Science Preparation Project* for the Texas Statewide Systemic Initiative.

References Cited

National Education Association. “NEA: 2001 Issue Paper-Rural Education.” Washington, DC: NEA, 2001.

Rural School and Community Trust. “Texas’ Rural Schools in Need of Policy Attention.” Washington DC: Rural School and Community Trust, 2003.

Center for Science Education, EDC. “Science Education Reform in Rural America: A Snapshot.” Newton: Education Development Center, Inc, 2002.

The Texas Statewide Systemic Initiative at the Charles A. Dana Center. "Texas Informal Science: Guidelines for Supporting the Improvement of Science, Mathematics, and Technology Education in Texas." Austin: The Dana Center at University of Texas at Austin, 1999.

Texas A&M Engineering News. “ ’Live science’ means better math, science scores for Texas’ rural students.” College Station: Texas A&M Engineering News Release, July 2002.

Hein, George E., and Mary Alexander. “Museums: Places of Learning.” Profiles of Texas Informal Science Education Providers: Connecting to Texas Schools. Austin: The Dana Center at University of Texas at Austin, 2001.

Busquin, Phillipe. EU Commissioner for Research. Keynote Speech at Naples ECSITE Conference, 2000.

Fort Worth Museum of Science and History TexNet Budget Justification

Fort Worth Museum of Science and History is developing the Texas Network for Exhibit-based learning and Teaching. Fort Worth will build local museums' capacity to provide science education by providing feeless traveling exhibitions that are coupled with extensive staff training in science-inquiry based education and community outreach.

A. Senior Staff at the Fort Worth Museum of Science and History (FWMSH)

Principal Investigator Charlie Walter (.05 FTE) will oversee the TexNET network at the FWMSH. He will work with Colleen Blair (.10), School Services Director, and Chip Lindsey (.10), Visitor Program Director, and Amanda Morales (.20), Visitor Program Assistant Director to create the TexNET partnership, administer the network, travel and maintain the exhibit sets, and provide a variety of support services. Walter, Blair, Lindsay and Morales will bring their experience in inquiry-based teaching and exhibit-based educational networks, based on the work of their Texas Center for Inquiry (TCI) and participation in the Exploratorium Network for Exhibit-based Teaching (ExNET). They will work with the local museums' directors -- Katie Powell of the Discovery Place, Tyler, Evelyn Smietana of the Laredo Children's Museum, and Sandy Henry of the Science Spectrum in Lubbock -- to train staff and develop programs based on the annually rotating exhibitions. Exploratorium staff are listed separately in the budget justification for the sub-awardee.

B. Other Personnel

Ft. Worth's will also devote Anne Herndon (.20) Visitor Outreach Coordinator, Dennis Gabbard (0.05) Exhibits Director and installation Technicians (.25 yrs 2-4) to develop visitor programs and to provide installation and maintenance services for the local museums. Supporting them will be an administrative assistant, (.10) for all 4 years of the project.

Local museum personnel will not receive any grant funding -- instead receiving 3 exhibitions, staff development, workshop participation, and consulting --; however, the dollars associated with their time will contribute to the cost share portion of the project, reducing the need for outside money during the first 4 years of the project. Each museum will have 3 positions with a combined time of .80 FTE dedicated to the project in the roles of education director, community outreach and floor staff.

C. Fringe Benefits — a fringe benefits rate of 13.5% has been applied to all salaries at Fort Worth and local museums. This rate includes sick, holiday, and vacation time, which has been deducted from the salary lines above.

D. Equipment — none

E. Travel

Workshop travel

A significant amount of capacity building in the form of workshops and training will take place in each year of the project. Specifically there are 3 types of consulting:

Partner Institutes, Exhibit-based Training Workshops, and Specialized Capacity Building Workshops. There will be a total of 5 Institutes (1 at each partner location) addressing common needs raised during preliminary planning meetings: approaches to inquiry learning, exhibition marketing, program design and development, institutional profile building, and community partnering. After a first year kick-off, there will be 3 Exhibit-based Training Workshops per year – one at each local museum. Finally, annual Specialized Capacity Building Workshops will take place at each local museum, addressing specific needs identified by the respective museums. Three members from each partner will participate in the Institutes, 2 staff from each museum will attend the kick-off Exhibit-based Training in Fort Worth. Subsequent on-site Exhibit-based Training Workshops will be led by 2 Fort Worth staff members and attended by 1 member from the non-host local museums. Specialized Capacity Building Workshops are co-lead by Fort Worth and Exploratorium staff, and attended by the local host only.

Other project related travel will stem from back-to-back advisor and kick-off planning meetings; annual installation, maintenance, and de-installation services; and annual partner meetings at the ASTC conference. It is expected that lead partners will cover their expenses to attend and meet at ASTC, while attendance and travel for one person per year from each local museum will be paid for by the project.

Air Fare – calculated at $300/trip in Texas, $750/trip to SFO and ASTC host cities
Local Transportation –covered in travel per-diems
Per-diems (calculated based on current govt. rates)
- Ft. Worth/Texas - $136/day
- Laredo - $104/day
- Lubbock - $85/day
- San Francisco and ASTC host cities - $209/day

Transportation — covered in shipping costs (G2 below) and travel per diems set forth above

F. Honorary Fees — advisors may receive up to $450 for their participation.

G. Other Costs

G1. Materials and Supplies

Educational Materials — although the primary educational resource will be the TexNET web site produced by the Exploratorium, both Fort Worth and the Exploratorium have budgeted for books, magazines, and activity guides, including bi-lingual materials.

Exhibit Materials and Spares — experience with the ExNET partnership has shown that cost for exhibit related spares and consumables can be kept to under $10,000 per year.

Marketing Materials and Supplies — include basic equipment, such as printers, and supplies to generate basic marketing materials in the form of brochures, flyers, handouts. Creative content will be generated during and after the Marketing Institute and is covered within the project, but expenses for media buying fall to the individual museums.

Meeting Materials and Supplies — provides for the advisor and planning meetings, as well as for the 3 types of workshops: Institutes, Exhibit-based Training Workshops, and Specialized Capacity Building Workshops.

G2. Dissemination/Shipping — shipping expenses will cover the expenses to rent a small truck and transport the exhibitions local museum to next. Rotations will occur every year – years 2-4.

G3. Consultant Services — Evaluation will be performed by Mark St. John and Inverness Research Associates, who are ideally suited to serve in such capacity based on their significant experience evaluating projects with similar aspects in terms of audience, exhibits, and model. These projects include studies of science education in rural communities (through NSF's Rural Systemic Initiatives), studies of informal science education to under-served communities (including NSF's Community Science Workshop project) and studies of exhibit development which include a collaborative component (TEAMS, Starter Sets, and Exhibit Resource Collaborative). They have also studied traveling exhibits to non-traditional venues (OMSI's National Science Outreach Network). The Inverness group knows the Texas context well as they evaluated the Texas Eisenhower program, and served as the evaluators for the initial Texas Center for Inquiry at the Fort Worth Museum of Science and History.

G6. Sub-Awardee — Fort Worth will be working with the Exploratorium, who will serve as a sub-awardee. See the Sub-Awardee budget justification for the narrative regarding expenses related to their sub-award.

I. Indirect Costs — calculated at the 15% of direct costs at Fort Worth and the other Texas museums. Fort Worth is currently in negotiations with NSF regarding indirect rate. In the case of consultant and sub-awardee expense, indirect costs apply to the first $25,000 per year only.

M. Cost Share — NSF funding will cover 75% of the direct project costs from the Fort Worth Museum of Science and History: the time contributed by the 3 local museum partners reduces the normal 33% cost share to 25%. Local museums will be reimbursed by Fort Worth for all travel expenses (except payroll) for attending workshops and other meetings. Fort Worth will seek private and corporate sources to cover the cost share portion. By the end of year 4, FWMSH plans to continue and expand TexNET, using the investment in the original exhibit sets as the seed for a sustainable network based on annual rental fees from local museums as well as sponsorship from a corporation interested in statewide science education initiatives.

Exploratorium (Sub-Awardee) TexNet Budget Justification

The Exploratorium will play a support role to the Fort Worth Museum of Science and History, supplying exhibits, educational materials, and consulting services. The Exploratorium will also open the existing ExNET partnership to the TexNET museums.

A. Senior Staff at the Exploratorium

Co-Principal Investigator Joe Hastings (.10, .10, .05, .05) will oversee the TexNET activity at the Exploratorium, interface with the other Network members through the staff at Fort Worth, and provide the resources of the ExNET program to the new partnership. He will be joined by Shawn Lani (.40, .10, .05, .05), Exhibit Developer, and Ken Finn (.25, .25, .10, .10), ExNET Education Director, to design and build the exhibits, develop the package of educational resources, and support the partnership by co-designing and co-leading workshops with Fort Worth, by performing exhibit-based training for local museum staff, and working with local staff to model compelling science programs for their community audiences.

B. Other Personnel

Many other staff from the Exploratorium will also participate in TexNET. Vivian Altmann (.10), Outreach Director, and her staff including Pablo Dela Cruz and Marco Jordan will contribute their significant experience in working with underserved, albeit urban, children by co-leading workshops and by helping with on-site programs. Exhibit production will take place entirely in year 1, led by Kua Patten, Production Manager, Dave Fleming, Senior Engineer, and other fabricators (total of 3.25 FTE). Exploratorium staff will perform the initial installation in Fort Worth, transferring the expertise to Fort Worth Staff, who will handle all subsequent installation, maintenance, and de-installation. Dave Barker (.25, .25, .10, .10), Art Director, will serve as Web / Media Developer, building and maintaining the TexNET web resource (based on, and connected to the existing ExNET site), which will be the clearinghouse for nearly all educational resources. Finally, administrative duties, initially connected with exhibit production and later with coordinating educational services, falls to Erica Gersowitz, Marketing Assistant (.15, .05, .05, .05).

C. Fringe Benefits — a fringe benefits rate of 38.69% has been applied to all salaries. This rate includes sick, holiday, and vacation time, which have been deducted from the salary lines.

D. Equipment — none

E. Travel — Travel for Exploratorium staff is included in the overall TexNET budget and will be coordinated and administered by Fort Worth staff. Exploratorium staff will take place in advisor and planning meetings (3 people each), co-lead the 5 TexNET partner Institutes (3 people each, except for the institute held at the Exploratorium which will draw on a greater number of staff), co-lead the first Exhibit-based Training Workshop in Fort Worth (2 people), co-lead the first on-site Exhibit-Based Training Workshops, and co-lead the Specialized Capacity Building Workshops held at the local museums (1 person). In each case, the Exploratorium will play a support role, learning together with Fort Worth and local partners how to provide interesting science programming to predominately rural, Hispanic audiences in Texas.

G. Other Costs

G1. Materials and Supplies

Exhibit Fabrication Materials — Total number of exhibits to be built is 33, divided into 3 sets of 11 exhibits on the topics of Motion, Weather, and Sound. Exhibit materials cost is calculated at $4,900 per exhibit, which is considerably less than the average cost of Exploratorium exhibits. However, the Exploratorium has significant experience building the same exhibits for the ExNET partnership and has been able to lower the cost while maintaining museum-level quality.

Exhibit Fabrication Materials (more) — Each set of exhibits will have a central, iconic element which will serve a dual purpose as organizing exhibit element (95%) and workshop activity area (5%). The central elements will not rotate with the other exhibits, but will stay put. Instead of traveling, renewal in the centerpieces will be accomplished in software, signage, video, sound, and lighting.

Exhibit Materials — Walls, area graphics, signage, lighting, and other exhibition elements that will serve to create a compelling space are included.

Shipping, Interstate — After 9 months of production, the exhibits will be shipped to Fort Worth for a 3 month dry run. Six years of experience with ExNET has shown that blanket wrapping without crates can be a successful shipping approach, which will reduce costs to the price of one truck. Return shipping is not included, because the exhibits will be given to the network after the proposed project term to maintain and further develop TexNET.

Educational Materials — See above.

G3. Consultant Services — The Exploratorium will hire Kurt Gabrielson (reference CV and commitment letter attached), a former staff member and founder of the Watsonville Taller de Ciencia Science Workshop in a low-income, agricultural community in northern California. Participants in the programs were 98% Mexican or Mexican-American. Kurt will co-lead a number of the Exhibit-based Training Workshops and Specialized Capacity Building Workshops, particularly those working with Spanish speaking children and families.

I. Indirect Costs — Indirect costs for the sub-award have been calculated at the NSF-negotiated rate of 32.1% on all Exploratorium direct costs, including the Consultant Services which are lower than the $25,000 per year ceiling.

M. Cost Share — The cost share percentage for the sub-awardee will be 33%. The Exploratorium will need to find additional matching grants from private and corporate sponsors.

TexNET APPENDICES

Appendix A: TexNET Partners Map

Appendix B: TexNET Regions Served

Appendix C: TexNET Exhibit Sets

Appendix D: TexNET Motion Exhibits - Images & Descriptions

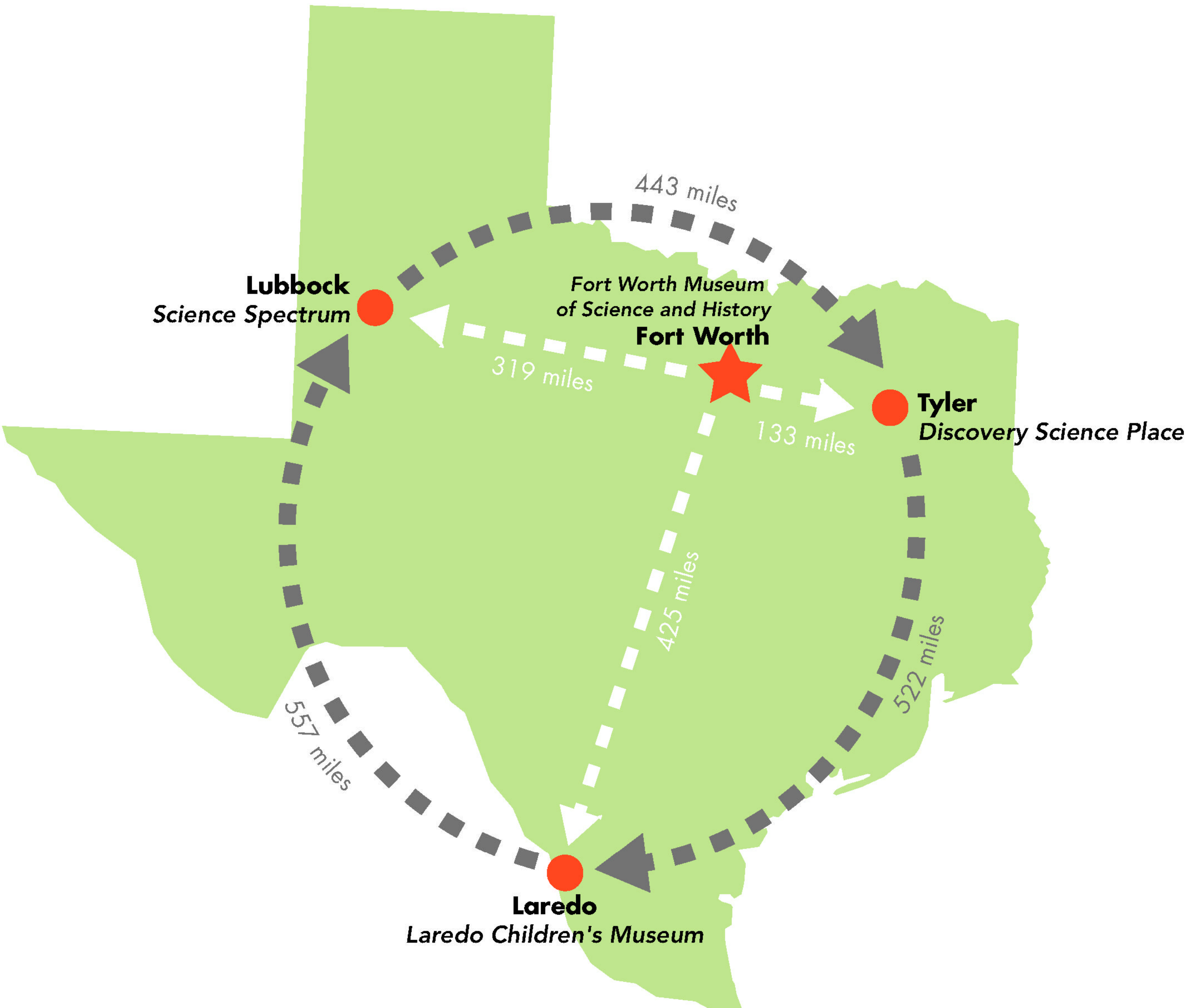
Appendix E: TexNET Motion Exhibits - Educational Materials and Resources

Appendix F: TexNET Motion Exhibits – Links to TEKS

Appendix G: TexNET Balancing Ball Exhibit "Snack"

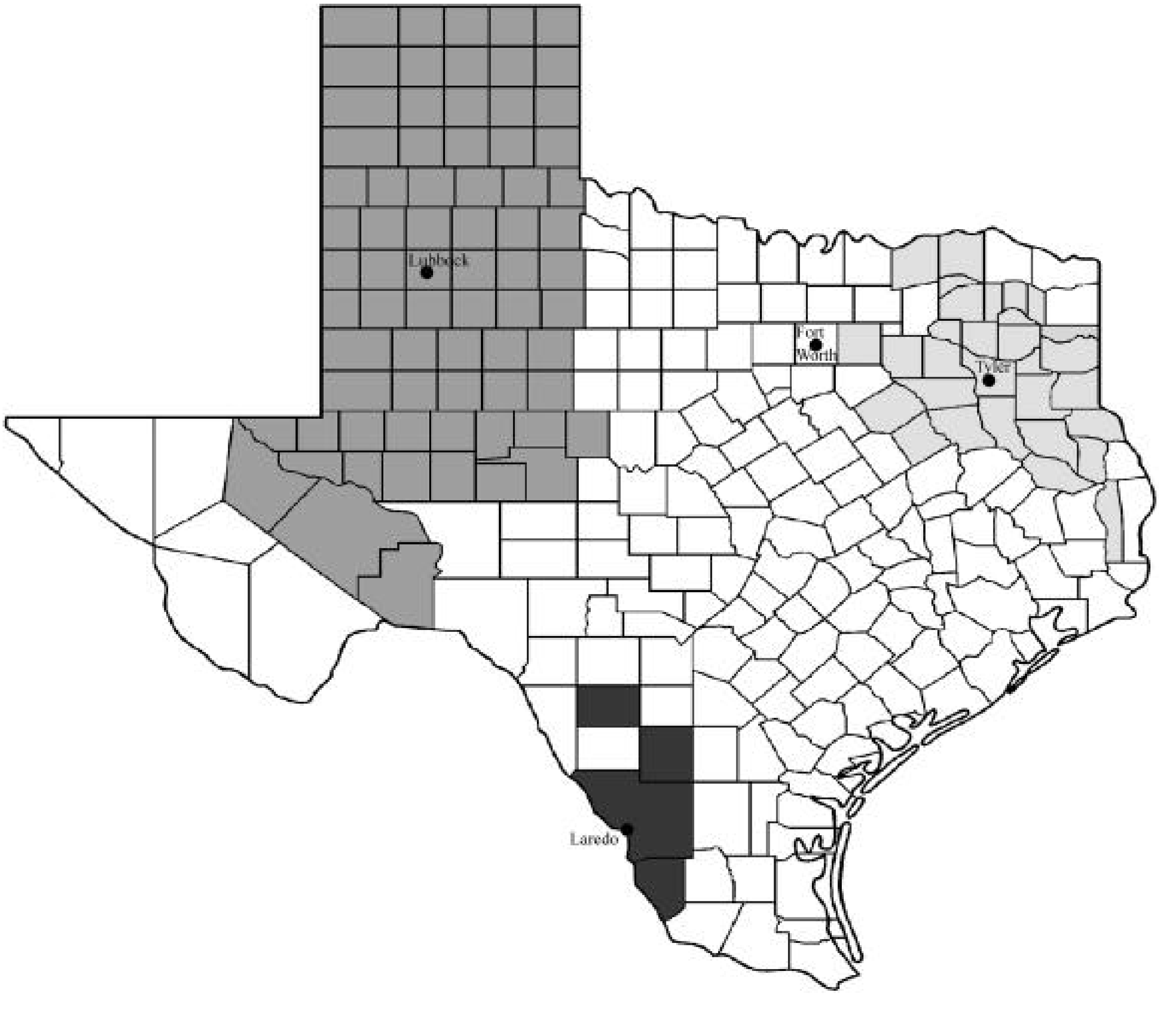
Appendix H: TexNET Balancing Ball Exhibit Web Page

Appendix A: TexNET Partners Map



TexNET: Texas Network for Exhibit-based Learning and Teaching

Appendix B: TexNET Regions Served



TexNET: Texas Network for Exhibit-based Learning and Teaching

Appendix C - TexNET Exhibit Sets

Motion
Animation Workstation
Balancing Ball
Bouncing Ball
Drawing Table
Fluttering Bridge
Motion Theater: Central Element
Pendulum Snake
Rope Squirter
Square Wheels
Strobe Flower
Turbulent Orb
Turntable

Weather
Chaotic Pendulum
Circling Wave Umbrella
Confused Sea
Convection Currents
Fog Chamber
Sea of Clouds
Settling Column
Tornado
Turbulent Orb
Weather Watch Station: Central Element
Wind Wall

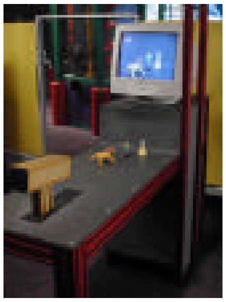
Sound
Big Tuning Fork
Circular Scales
Delayed Speech
Doppler Effect
Echo Tube
Find the Highest Note
Hole Saw Rhythms
Pipes of Pan
Sound Box: Central Element
Visible Effects of the Invisible
Vocal Vowels

Appendix D: TexNET Motion Exhibits

TexNET: Texas Network for Exhibit-based Learning and Teaching

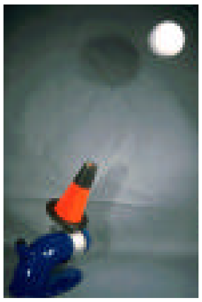
Appendix D: TexNET Motion Exhibits

Animation Workstation



Visitors create animated movies using clay or movable objects. The interface is fast and intuitive and the image quality is excellent. Purchased from Creative Machines, Inc.

Balancing Ball/Bernoulli Blower



At Balancing Ball, a plastic beach ball floats mysteriously several feet above a large plastic cone. Upon closer inspection, the ball is found to be floating on a stream of air blowing out of the cone, generated by a large fan beneath it. If the ball is pulled slowly out of the stream of air, a force is felt in trying to pull the ball back into the air stream. If the cone is bent to the side, the ball can be suspended in space off to the side of the cone.

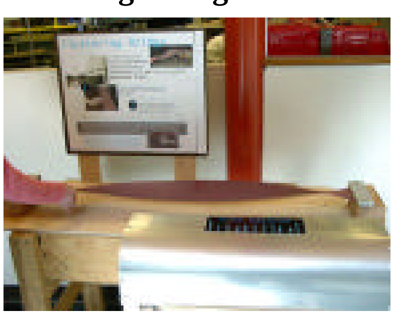
Bouncing Ball

Bouncing Ball shines light on the behavior of a steel ball bouncing on a hardened steel plate by highlighting the exponential decay of the motion and the corresponding increase of the frequency of the bounces. Visitors use a magnet to lift the ball above the plate where it is automatically dropped. The sounds of the bouncing are amplified and played through speakers. When the plate is clean, the frequency of the bounce reaches several hundred hertz.

Drawing Table

Drawing Table is a favorite at the Exploratorium. Children line up to make a drawing, using pens and a swinging table to create complex and beautiful patterns. An attendant places different colored pens in the holder, and the visitor swings the table, making any of a number of patterns.

Fluttering Bridge



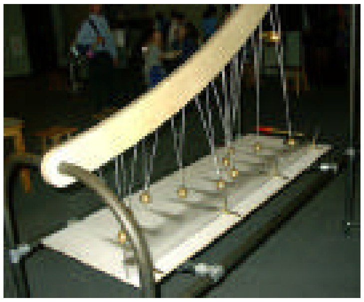
Fluttering Bridge is an interactive bridge failure demonstration, modeled after the Tacoma Narrows Bridge collapse in Tacoma Washington. Air blows perpendicular to the rubber "bridge". The user can experiment by changing the fan speed and pinching the rubber in different locations to create varying wave patterns. When the leading edge of the band is pinched to simulate an asymmetrical structure, it causes the wind to unevenly flow past the band, causing the band to resonate. The resonance builds on each wave, and the fluttering increases. Fluttering Bridge is a fantastic teaching tool for studying resonance and elastic vs. dampened structures, especially relating to bridge design.

Appendix D: TexNET Motion Exhibits

Motion Theater

The Motion Theater is a cozy replica of an old movie house. Exploratorium Film Program Director Liz Keim curates a selection of classic non-narrative films exploring the science, beauty, and wonder inherent in the topic of motion.

Pendulum Snake

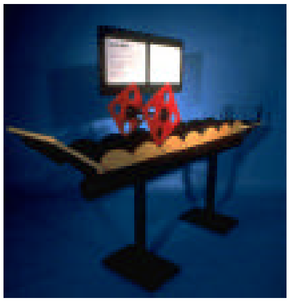


Ten brass weights hang from strings of different lengths. Visitors activate the array of pendulums, which swing back and forth. The timing of each pendulum's motion depends upon its length. Although the weights swing independently, they appear to move together, first in a line, then as a snake. After several periods, the motion becomes seemingly random, and then gradually organizes itself again as the snake pattern returns and the cycle repeats.

Rope Squirter

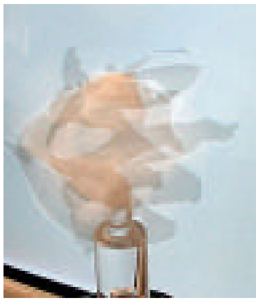
A loop of string is thrown by a pulley attached to a spinning motor. Visitors twist the motor, causing the string to move in interesting ways. As the string hits various objects, including funnels, blocks, arms and hands, it takes on many shapes - some predictable, and others unexpected.

Square Wheels



In Square Wheel, an ten-inch square wheel rolls smoothly across a very bumpy surface. The bumps are carefully designed, flat catenary curves which exactly match the sides of the wheel in length. These curves also exactly compensate for the changing axle height of the square wheel as it rolls along. The axle of the wheel does not move up and down. Extensive graphics explain the exhibit.

Strobe Flower

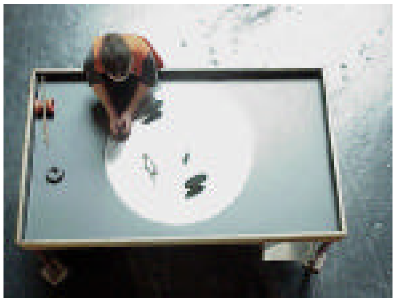


Strobe flower takes advantage of the strobing or raster scanning of a common computer screen. By twirling a small scrap of semi-translucent plastic grocery bag in front of a blank computer screen, visitors create delicate and intricate shapes reminiscent of flowers and insects. Varying the motor's speed and touching the twirling shapes, visitors are able to adjust the "flower" into and out of phase with the computer screen's strobing frequency. The resulting "flowers" are both ghostly and beautiful as they spin unpredictable patterns of shape and color.
Strobe Flower was developed in partnership with the Palace of Miracles in Budapest, Hungary.

Turbulent Orb

The Turbulent Orb is a large polycarbonate sphere full of special, colored, flow-visualization fluid, otherwise known as dishsoap, water, and food coloring. The sphere is mounted on top of a pedestal and can be spun in either direction and at different speeds. The fluid in the sphere shows swirls and waves of internal fluid motions produced by the actions of the visitors. The turbulence of the fluid in the sphere is reminiscent of the turbulent flows that occur in planetary atmospheres. This exhibit shows the complexities of fluid motion that can be produced by very simple circumstances.

Turntable



The Turntable disk rotates like a giant compact disk. A supply of small metal disks, rings, and balls, 7-10 cm in diameter, is scattered around the stationary portion of the table top. Visitors try to keep the rings on their edge spinning on the disk. They discover that a ring spinning on edge may stay on the turntable for a while, orbiting the center. A disk laid flat will move in a straight line as soon as it slides off the turntable. Visitors, especially children, love the challenge of getting the disks and rings to stand on edge while moving around the Turntable.

Appendix E: TexNET Motion Exhibits - Educational Materials and Resources

Balancing Ball

Try different objects at the exhibit… football, plastic egg, golf ball, etc.
Use hair dryer & ping-pong balls, Snackbook, *classroom, after school, family*
Use drinking straws and Ping-Pong balls, *classroom, after school, family*
Helicopter launcher at the exhibit, Science Explorer

Bouncing Ball

Radioactive decay model, Snackbook, *classroom*

Drawing Table

Moiré patterns exploration, Online, *classroom, after school, family*
Strange attractor model, Snackbook, *classroom, after school*
Sand table and plumb bob, *classroom, after school*
Phosphorescent material and flashlight pendulum, *classroom, after school*

Fluttering Bridge

Clothespin harmonica, a rubber band sandwiched inside a clothespin vibrates
When you blow, Online, *classroom, after school, family*
The Tingler, a paper reed toy, Science Explorer, *after school, family*
String machine, Square Wheels Snackbook, *classroom, after school*

Pendulum Snake

Pendulum with nuts and string, TI Activity, *classroom, family*
Flip books, Online, *after school, family*

Rope Squirter

Straw w/cassette tape, *class room, after school, family*
Straw w/ a string, *classroom, after school, family*
Ribbon on stick (from rhythmic gymnastics), *after school, family*
Cowboy rope tricks
String Thing, Store Product, after school, family

Square Wheels

The snack, Square Wheels Snackbook, *classroom, after school, family*
Create gears using jar lids and corrugated cardboard, Make it Work! Machines, *classroom, after school, family*

Strobe Flower

Flip Sticks, Science Explorer, *classroom, after school, family*
Zoetrope, Online, *class room, after school, family*
Flip Book, Online, *after school, family*
Strobe light play, *class room, after school, family*

Turbulent Orb

Snack version - soap in juice bottle, Snackbook, *classroom, after school, family*
Convection cells with hot plate and pie pan, Online, *classroom, family*
Turbulence inquiry using large trays *class room, after school*
Food coloring in various temperatures of water *classroom, after school, family*

Turntable

Momentum machine in office chair, Snackbook, *classroom, after school*
Film can racer snack, Square Wheels, *classroom, after school, family*
Tops and rotational inertia activity, Online, *classroom, after school, family*

Texas Essential Knowledge and Skills (TEKS) - Science Standards

112.2 Kindergarten

	Animation Workstation	Balancing Balls	Bouncing Ball	Drawing Table	Fluttering Bridge	Pendulum Snake	Rope Squirter	Square Wheels	Strobe Flower	Turbulent Orb	Turntable
(a) Introduction											
(1) Investigate Using Senses & Tools	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Learning Through Models	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Basic Properties of Systems and the Components that make them	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(5) Learning Through Investigation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(b) Knowledge and skills											
(2) Science Inquiry Processes - student develops abilities to do scientific inquiry in the field & the classroom. The student is expected to:											
(A) Ask Questions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Plan and Conduct Experiments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Gather Information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(D) Construct Reasonable Explanations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(E) Communicate Findings	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Scientific Processes - students knows that information and critical thinking are used in making decisions. The student is expected to:											
(A) Make Decisions Using Information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Discuss and Modify Decisions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Explain a Problem and Propose a Solution	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Scientific Processes - student uses age-appropriate tools and models to verify that organisms and objects and parts of organisms and objects can be observed, described, and measured. The student is expected to:											
(A) Identify and use senses as tools of observation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Make observations using tools	✓	✓	✓	✓	✓	✓			✓		
(5) Science Concepts - student knows that organisms, objects, and events have properties and patterns. The student is expected to:											
(A) Describe Properties of Objects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Observe and Identify Patterns	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(7) Science Concepts - student knows that many types of change occur. The student is expected to:											
(A) Observe, describe, and record changes in size, mass, color, position, quantity, time, temperature, sound, and movement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

112.3 Grade 1

	Animation Workstation	Balancing Balls	Bouncing Ball	Drawing Table	Fluttering Bridge	Pendulum Snake	Rope Squirter	Square Wheels	Strobe Flower	Turbulent Orb	Turntable
(a) Introduction											
(1) Simple classroom and field investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Learning through models	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Systems as collections of cycles, structures, and processes that interact.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(5) Learn through investigation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(b) Knowledge and Skills											
(2) Scientific processes - The student develops abilities necessary to do scientific inquiry in the field and the classroom. The student is expected to:											
(A) Ask questions about organisms, objects, and events	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Plan and conduct simple descriptive investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Gather information using simple equipment and tools to extend the senses	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(D) Construct reasonable explanations and draw conclusions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(E) Communicate explanations about investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Scientific processes - The student knows that information and critical thinking are used in making decisions. The student is expected to:											
(A) Make decisions using information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Discuss and justify the merits of decisions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Explain a problem in his/her own words and identify a task and solution related to the problem	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Scientific processes - The student uses age-appropriate tools and models to verify that organisms and objects and parts of organisms and objects can be observed, described, and measured. The student is expected to:											
(A) Collect information using tools	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Record and compare collected information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Measure organisms and objects and parts of organisms and objects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(5) Science concepts - The student knows that organisms, objects, and events have properties and patterns. The student is expected to:											
(A) Sort Objects based on Properties	✓				✓	✓					✓
(B) Identify, Create, and Predict Patterns	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(7) Science concepts - The student knows that many types of change occur. The student is expected to:											
(A) Observe, measure, and record changes in size, mass, color, position, quantity, sound, and movement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

112.4 Grade 2

Texas Essential Knowledge and Skills (TEKS) - Science Standards	Animation Workstation	Balancing Balls	Bouncing Ball	Drawing Table	Fluttering Bridge	Pendulum Snake	Rope Squirter	Square Wheels	Strobe Flower	Turbulent Orb	Turntable
(a) Introduction											
(1) Simple Classroom and Field Investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Learning through Models	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Systems as Collections of Components	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(5) Learn through Investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(b) Knowledge and Skills											
(2) Scientific processes - The student develops abilities necessary to do scientific inquiry in the field and the classroom. The student is expected to:											
(A) Ask questions about organisms, objects, and events	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Plan and and conduct simple descriptive investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Compare results of investigations with what students and scientists know	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(D) Gather information using simple equipment and tools to extend the senses	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(E) Construct reasonable explanations and draw conclusions using information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(F) Communicate explanations about investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Scientific processes - The student knows that information and critical thinking are used in making decisions. The student is expected to:											
(A) Make decisions using information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Discuss and Justify Decisions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Explain a problem and propose a solution	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Scientific processes - The student uses age-appropriate tools and models to verify that organisms and objects and parts of organisms and objects can be observed, described, and measured. The student is expected to:											
(A) Collect information using tools	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Measure and compare organisms and objects and parts of organisms and objects, using standard and non-standard units	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(5) Science concepts - The student knows that organisms, objects, and events have properties and patterns. The student is expected to:											
(B) Organisms, Objects, & Events have Properties and Patterns. Identify, Predict, Replicate, Create Patterns	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(7) Science concepts - The student knows that many types of change occur. The											
(A) Observe, Measure, Record, Analyze, Predict, Illustrate Changes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Demonstrate a change in the motion of an object by giving the object a push		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

112.5 Grade 3

Texas Essential Knowledge and Skills (TEKS) - Science Standards	Animation Workstation	Balancing Balls	Bouncing Ball	Drawing Table	Fluttering Bridge	Pendulum Snake	Rope Squirter	Square Wheels	Strobe Flower	Turbulent Orb	Turntable
(a) Introduction											
(1) Planning andimplementing classroom and field investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(2) Identify the importance of and observe the effects of force		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Learning through models	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Systems as collections of components	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(5) Learn through investigations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(b) Knowledge and Skills											
(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. The student is expected to:											
(A) Plan and implement descriptive investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using equipment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Collect information by observing and measuring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(C) Analyze and interpret information to construct reasonable explanations from direct and indirect evidence	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(D) Communicate valid conclusions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(3) Scientific processes -The student knows that information, critical thinking, and scientific problem solving are used in making decisions. The student is expected to:											
(A) Analyze review, and critique scientific explanations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. The student is expected to:											
(B) Demonstrate that repeated investigations may increase the reliability of	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(5) Science concepts - The student knows that systems exist in the world. The											
(A) Observe and identify simple systems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(B) Describe its parts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(6) Science concepts - The student knows that forces cause change. The student is											
(A) Measure and record changes in the position and direction of the motion of an object to which a force such as a push or pull has been applied		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Texas Essential Knowledge and Skills (TEKS) - Science Standards

112.6 Science Grade 4

Standard	Animation Workstation	Balancing Balls	Bouncing Ball	Drawing Table	Fluttering Bridge	Pendulum Snake	Rope Squirter	Square Wheels	Strobe Flower	Turbulent Orb	Turntable
(a) Introduction											
(1) Planning and implementing classroom and field investigations	x	x	x	x	x	x	x	x	x	x	x
(4) Learning through models	x	x	x	x	x	x	x	x	x	x	x
(5) Systems as collections of components	x	x	x	x	x	x	x	x	x	x	x
(6) Learning through investigation	x	x	x	x	x	x	x	x	x	x	x
(b) Knowledge and Skills											
(2) Scientific processes - The student uses scientific inquiry methods during field and laboratory investigations. The student is expected to:											
(A) Plan and implement descriptive investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using equipment and technology	x	x	x	x	x	x	x	x	x	x	x
(B) Collect information by observing and measuring	x	x	x	x	x	x	x	x	x	x	x
(C) Analyze and interpret information to construct reasonable explanations from direct and indirect evidence	x	x	x	x	x	x	x	x	x	x	x
(D) Communicate valid conclusions	x	x	x	x	x	x	x	x	x	x	x
(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:											
(A) Analyze and review scientific processes	x	x	x	x	x	x	x	x	x	x	x
(C) Represent the natural world using models and identify their limitation	x	x	x	x	x	x	x	x	x	x	x
(4) Scientific processes - The student knows how to use a variety of tools and methods to conduct science inquiry. The student is expected to:											
(A) Collect and analyze information using tools	x	x	x	x	x	x	x	x	x	x	x
(B) Demonstrate that repeated investigations may increase the reliability of	x	x	x	x	x	x	x	x	x	x	x
(5) Science concepts - The student knows that complex systems may not work if some parts are removed. The student is expected to:											
(A) Identify and describe roles of parts of a non living system	x	x	x	x	x	x	x	x	x	x	x
(B) Predict and draw conclusions about what happens when part of a system is removed.		x	x		x	x	x	x	x		x
(6) Science concepts -The student knows that change can create recognizable patterns. The student is expected to:											
(A) Identify patterns of change	x	x	x	x	x	x	x	x	x	x	x

112.7 Science Grade 5

Standard	Animation Workstation	Balancing Balls	Bouncing Ball	Drawing Table	Fluttering Bridge	Pendulum Snake	Rope Squirter	Square Wheels	Strobe Flower	Turbulent Orb	Turntable
(a) Introduction											
(1) Planning and implementing field investigations	x	x	x	x	x	x	x	x	x	x	x
(4) Learning through models	x	x	x	x	x	x	x	x	x	x	x
(5) Systems as collections of components	x	x	x	x	x	x	x	x	x	x	x
(6) Learning through investigation	x	x	x	x	x	x	x	x	x	x	x
(b) Knowledge and Skills											
(2) Scientific processes - The student uses scientific methods during field and laboratory investigations. The student is expected to:											
(A) Plan and implement descriptive investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using equipment and technology	x	x	x	x	x	x	x	x	x	x	x
(B) Collect information by observing and measuring	x	x	x	x	x	x	x	x	x	x	x
(C) Analyze and interpret information to construct reasonable explanations from direct and indirect evidence	x	x	x	x	x	x	x	x	x	x	x
(D) Communicate valid conclusions	x	x	x	x	x	x	x	x	x	x	x
(3) Scientific processes - The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:											
(A) Analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information	x	x	x	x	x	x	x	x	x	x	x
(C) Represent the natural world using models and identify their limitations	x	x	x	x	x	x	x	x	x	x	x
(4) Scientific processes -The student knows how to use a variety of tools and methods to conduct science inquiry. The student is expected to:											
(A) Collect and analyze information using tools	x	x	x	x	x	x	x	x	x	x	x
(B) Demonstrate that repeated investigations may increase the reliability of	x	x	x	x	x	x	x	x	x	x	x
(5) Science concepts - The student knows that a system is a collection of cycles, structures, and processes that interact. The student is expected to:											
(A) Describe some cycles, structures, and processes that are found in a simple system	x	x	x	x	x	x		x	x	x	x
(6) Science concepts. The student knows that some change occurs in cycles. The student is expected to:											
(A) Identify and describe changes in a regular cycle	x	x	x	x	x	x	x	x	x	x	x

Balancing Ball

Suspend a ball in a stream of air

A ball stably levitated on an invisible stream of air is a dramatic sight. When you try to pull the ball out of the airstream, you can feel a force pulling it back in. You can also feel that the airstream is being deflected by the ball. This Snack shows one of the forces that give airplanes lift.

materials :

Small Snack

- A hair dryer (blower)
- A spherical balloon or table tennis ball
- Tissue paper
- Optional: a stand for the blower

Large Snack

- A vacuum cleaner (It should come with a reversible hose, like a Shop Vac has, so it can be used as blower.)
- A light-weight vinyl beach ball
- Tissue paper
- Optional: a stand for the hose

assembly :

None required. Note, though, that you can make a large or a small Snack (see "Materials"). Depending on the blower you choose, some experimentation may be necessary to find a satisfactory ball. You might want a partner to help you, or you can devise some sort of stand for the blower. That way, your hands will be free to experiment with the ball in the airstream.

to do and notice : (5 minutes or more)

Blow a stream of air straight up. Carefully balance the ball above the airstream. Pull it slowly out of the flow. Notice that when only half the ball is out of the airstream, you can feel it being sucked back in. Let go of the ball and notice that it oscillates back and forth and then settles down near the center of the airstream.

With one hand, pull the ball partially out of the airstream. With the other hand, dangle a piece of tissue paper and search for the airstream above the ball. Notice that the ball deflects the airstream outward. On the large version of this Snack, you can actually feel the deflected airstream hit your hand.

Tilt the airstream to one side and notice that the ball can still be suspended.

Balance the ball in the airstream and then move the blower and the ball toward a wall (try the corner of a room). Notice the great increase in height of the suspended ball.

what’s going on?

When the ball is suspended in the airstream, the air flowing upward hits the bottom of the ball and slows down, generating a region of higher pressure. The high-pressure region of air under the ball holds the ball up against the pull of gravity.

When you pull the ball partially out of the airstream, the air flows around the curve of the ball that is nearest the center of the airstream. Air rushes in an arc around the top of the ball and then continues outward above the ball.

This outward-flowing air exerts an inward force on the ball, just like the downward flow of air beneath a helicopter exerts an upward force on the blades of the helicopter. Thisexplanation is based on Newton's law of action and reaction.

Another way of looking at this is that as the air arcs around the ball, the air pressure on the ball decreases, allowing the normal atmospheric pressure of the calm air on the other side of the ball to push the ball back into the airstream.

People immediately raise several questions when they hear the second explanation:

Why does air flowing over a surface in an arc exert less pressure on that surface? To answer this question, consider a rider in a roller coaster going over the top of a hill at high speed. The force that the rider exerts on the seat decreases as the rider goes over the top of the hill. In the same way, the air that arcs around the side of the ball exerts less force on the ball.

Why does air follow the surface of the sphere? Consider what would happen if the air did not curve around the ball. An "air shadow" would be formed above the ball. This air shadow would be a region of low pressure. The air would then flow into the low-pressure air shadow. So the air flows around the ball.

An alternative explanation is provided by the Bernoulli principle. If you pull the ball far enough out of the airstream, then the air flows over only one side of the ball. In fact, the airstream speeds up as it flows around the ball. This is because the middle of the ball sticks farther into the airstream than the top or bottom. Since the same amount of air must flow past all parts of the ball each second, it must flow faster where it is pinched together at the middle. The Bernoulli principle states that where air speeds up, its pressure drops. The difference in pressure between the still air and the moving air pushes the ball back into the center of the airstream.

When you approach a wall with the balanced ball, the highpressure region under the ball becomes a region of even higher pressure. The air that hits the bottom of the ball can no longer expand outward in the direction of the wall. The higher pressure drives the ball to a greater height.

etcetera :

This exhibit illustrates one of the reasons that airplanes fly. A flat wing will fly if it is tipped into the wind, so that it forces air downward. Newton's third lawtells us that for every action there must be an equal and opposite reaction: The reaction to the downward force of the wing on the air is the upward force of the air on the wing. You can feel this lifting force if you hold your hand out the window of a moving car and tip your hand so that it forces the air downward.

A wing that is curved on top will deflect air downward and produce lift even if it isn't tipped. The explanation for this is essentially the same as the one given in this Snack. The wing collides with air, creating a region of high pressure in front of the wing. This high pressure produces drag, which is always associated with lift. The high-pressure air in front of the wing accelerates air over the curved surface of the wing. This air then flows downward behind the wing. Airplane fly because their wings throw air downward.

It is sometimes said that air must flow faster over the curved top surface of a wing than over the flat bottom. This is said to happen because the air has to meet up again at the far end of the wing, and since the air traveling over the curved path must travel farther, it must travel faster. This is not true. Two parcels of air that start together, then split to flow over different sides of a wing, do not, as a rule, rejoin at the far end of the wing.

Appendix H: TexNET Balancing Ball Exhibit Web Page