**Wonderwise 4-H: Following in the Footsteps of Women Scientists**

**Abstract**

*Wonderwise 4-H: Women in Science* introduces youth to contemporary female scientists in their labs, out in the field, and with their families through nine interactive multimedia kits. Youth learn about the scientist’s occupation and participate in hands-on science activities similar to the actual work of a female scientist role model. Using role models was effective in improving youths’ attitudes about science through engaging activities and realistic videos. A web survey of 150 adult youth leaders showed Wonderwise 4-H brings “real science” into youths’ lives by (a) engaging them in actual scientific activities, (b) increasing their understanding of what science is, and (c) broadening their view of who scientists are, what they do, and where they work. It encourages youth to pursue science in their future by (a) helping them become more confident and capable at scientific endeavors, (b) increasing their understanding of the possibilities of a science career, and (c) connecting them in a personal way with scientist role models.

Wonderwise 4-H is a model for how museums and 4-H can work together to improve nonformal science education; 4-H took advantage of a unique opportunity, and the museum reached beyond its usual constituents. Project dissemination was primarily through existing 4-H networks in partner states. The success of this project suggests that opportunities for science learning can be enhanced through innovative collaborations of nonformal educational partners.

Wonderwise 4-H is included in the 2003 National 4-H Curriculum Collection. For more information see [www.wonderwise.unl.edu](http://www.wonderwise.unl.edu).

This material is based upon work supported by the National Science Foundation under Grant No. 9909496.
Girls lag behind boys in science achievement as they progress from elementary grades into high school (O’Sullivan, Reese, & Mazzeo, 1997); they are less likely than boys to pursue scientific careers, even those academically inclined and talented (Matyas & Dix, 1992; National Science Board, 1993, 1998). Youth from rural areas, especially those with few role models for scientific careers, have little knowledge about career opportunities and limited aspirations for scientific vocations (Crockett, Shanahan, & Jackson-Newsome, 1996; Haller & Vickler, 1993; Sarigiani, Wilson, Petersen, & Vicary, 1990). The lack of accurate information about science careers, along with gender role stereotyping, limit girls’ career choices and expectations for success (Baker & Leary, 1995; Eccles, 1986). Scientists are usually portrayed, whether in textbooks or on television, as male (Steinke & Long, 1996) and most girls lack personal acquaintance with scientists, particularly those who are women (Hill, Pettus, & Hedin, 1990). Baker (1987) suggests that exposing girls to outstanding female role models may encourage them to pursue science as a career.

To address the issues of rural isolation and lack of role models for young girls, NSF funded Wonderwise 4-H, a major collaborative project between the University of Nebraska State Museum and the 4-H Youth Development program, to enhance nonformal youth education. Museums and 4-H have common educational goals with long histories of using experiential methods for teaching science. Museums reach out to youth using hands-on experiences for educational activities, and museum kits have long been a resource for teachers and other educators; 4-H curricula apply scientific principles in youth programs that build life skills as youth prepare for future vocations. The experiential learning model and the inquiry-based science approach link directly to two national guidelines that ensure quality youth programs: the National Science Education Standards (National Research Council, 1996) and Cooperative Extension's Science Guidelines for Nonformal Education (Carlson & Maxa, 1997).

The NSF grant in 2000 was the catalyst for the Museum and 4-H to form a consortium. The Museum was the lead partner for developing Wonderwise 4-H kits while 4-H’s primary responsibility was testing the kits in nonformal education settings, providing feedback, and disseminating the kits. When 4-H State Leaders from 10 states (Illinois, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, and Wyoming) agreed to participate in the project, they agreed to engage staff and volunteer leaders to (a) field test six classroom-based Wonderwise kits developed in the early 1990s in a nonformal educational setting and provide suggestions for altering the kits, (b) participate in workshops to learn how to use the Wonderwise 4-H kits, (c) disseminate kits in their states, and (d) participate in evaluating Wonderwise 4-H. In return, each state received grant dollars to purchase kits and kit supplies, as well as museum resources to learn more about the kits. State 4-H Leaders generally appointed a 4-H State Specialist the responsibility for implementing Wonderwise 4-H in their state.

**Wonderwise 4-H: Its Design, Development, and Dissemination**

Six Wonderwise kits were developed for classroom use in the mid-1990’s. Thorough testing occurred while the kits were designed and field tested in formal classroom settings; extensive evaluation documented their value before being widely disseminated to elementary school teachers in Nebraska (Spiegel, Dethlefs, & Pytlik Zillig, 1997). In 2000, the University of Nebraska State Museum collaborated with 4-H Youth Development to redesign
Wonderwise into Wonderwise 4-H so it would also be appropriate for nonformal educational settings. Wonderwise 4-H was designed as an experiential learning activity to:

a. motivate 8- to 12-year old youth, particularly girls, to pursue an interest in science and an awareness of scientific activities and careers,
b. create a positive image of women and minority scientists for 4-H youth,
c. improve diversity and quality of 4-H’s out-of-school science materials by offering materials that are inquiry-based, multicultural and tie science activities to the work of real scientists,
d. help youth connect agricultural topics and their underlying scientific principles, and
e. instil in youth a better appreciation of empirically-based knowledge and enhance children’s ability to use scientific reasoning.

Pedagogical Approach and Curriculum Design

Carlson and Maxa (1998) recommended using hands-on activities in nonformal youth education programs. The National Science Education Standards (National Research Council, 1996), reports from Project 2061 (a biological and health science project) funded by the American Association for the Advancement of Science (Clark, 1989), and lessons learned from a 1993 W. K. Kellogg Foundation project on How to Unravel Science Mysteries for Young Minds all emphasize that curricula for science education needs to use participatory, inquiry-based activities to enable students to explore, and then work independently or collaboratively, to construct their own meaning and knowledge about scientific career opportunities. Consequently, the experiential learning model was selected as the pedagogical approach for Wonderwise 4-H.

The packaging of the six original Wonderwise kits was redesigned after 4-H’ers and 4-H leaders suggested ways to make the kit contents more appropriate for their use. Their suggestions on format, topics, materials, and kit structure called for keeping content the same but integrating more user-friendly technology into one slipcover that would fit on any bookshelf. Three integrated components comprise each Wonderwise 4-H kit: (a) a videotape, (b) five hands-on, inquiry-based scientific activities, and (c) a CD-ROM (Table 1).

Table 1
Wonderwise 4-H Kit Components

<table>
<thead>
<tr>
<th>Kit component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videotape</td>
<td>A 15- to 20-minute video profile of the scientist and her work. This &quot;virtual field trip&quot; takes youth around the world, into the scientist’s laboratory and out on field site activities as she explains and goes about her work.</td>
</tr>
<tr>
<td>Youth activities</td>
<td>The hands-on, inquiry-based science activities are closely related to the scientists’ work. They are printed on loose 8 ½ x 11” sheets and take approximately 30 minutes to complete; they can be used in 60- or 90-minute educational sessions. Consumables required are readily available in any classroom or field office.</td>
</tr>
<tr>
<td>CD-ROM</td>
<td>An interactive CD-ROM contains a biography of the scientist, downloadable and printable versions of the activity sheets in both English and Spanish, a copy of the video, and additional resources and activities.</td>
</tr>
</tbody>
</table>
Nine Multimedia Wonderwise 4-H Kits

The six original Wonderwise kits were redesigned and three new kits were developed for Wonderwise 4-H. The six original topics targeted upper elementary age children ages 9 to 11; the three new topics, Space Geologist, Vet Detective, and Genetic Counselor, enable extending the project to a 12- to 14-year-old audience.

Each kit focuses on a different woman scientist’s research. The women’s scientific specializations range from wildlife biology to genetic researcher; the wide-ranging topics are explored through diverse activities (Table 2). Wonderwise 4-H’s web site (www.unl.wonderwise.edu) includes a complete set of free, downloadable activities for every kit in both English and Spanish, brief previews of the videos, and additional resource information.

Table 2
A Sample of the Scientists, Topics and Kit Contents for Wonderwise 4-H

<table>
<thead>
<tr>
<th>Scientist and scientific topic</th>
<th>Summary of videos and supporting activities</th>
</tr>
</thead>
</table>
| 1. Jannalee Caldwell: Rainforest Ecologist | Video: Dr. Caldwell treks deep in to the rainforests. She counts and collects frogs and insects to learn more about the rainforest and the fascinating life it supports.  
Science Activities:  
• Nutty Investigations: test the strength and fat content of different nuts  
• Frogs Up Close and Personal: design backgrounds to made poison frogs disappear and stand out  
• Build a Tree: construct a sturdy rain forest tree from scratch  
• Rain Forest in Your Room: create a rain forest community of plants and animals  
• Life in a Nutshell Game: grow your critter from egg to larva to adult in the Brazil nut board game |
| Fatimah Jackson: African Plant Explorer | Video: Dr. Jackson travels to Africa to study local plants that serve as food and medicine. She takes samples of the remarkable plants back to her laboratory to study.  
Science Activities:  
• Everyday Poisons: discover the poisons in everyday foods  
• Investigating Starch: examine the chemical properties of starch  
• African Arts: use cassava to batik African symbols onto cloth in a two-day activity  
• Green Travelers: follow the world travels of common foods throughout history |
| Adriana Ocampo: Space | Video: Dr. Ocampo searches through Belize and neighboring |
Geologist
Adriana Ocampo, Ph.D., helped determine the surface outline of the buried impact crater at Chixulub, Mexico. Her discovery helped prove that an asteroid caused the extinction of the dinosaurs.

Science Activities:
- Meet Adriana: learn what a space geologist does and the anatomy of an asteroid impact
- Crater Maker: make an impact and investigate how craters take shape
- Vanishing Craters: test the effects of weather on the surface of craters
- Big Time Tour: explore Earth’s history from your shoulder to your fingertips
- Digging Into the Past: create a set of strata, take a core sample, and learn how to read the past

Mexico for traces of a crater caused by an asteroid that hit Earth 65 million years ago. She compares craters that exist on other planets with ones on Earth.

4. Tolani Francisco: Vet Detective
Tolani Francisco, DVM, works in veterinary medicine all over the world to help native people protect their wildlife and their land.

Video: Dr. Francisco travels to Native American reservations to check the health of bison and elk. Her challenge is to stop the spread of animal diseases using the science behind traditional Native values.

Science Activities:
- Meet Tolani: explore how close people can safely get to animals
- Bison Behavior: learn how to make sense of bison behavior
- Vital Signs: take your vital signs and compare your data to the vital signs of other animals
- Ruminante: compare animal digestive systems and then simulate the process of digesting grass
- Disease Detective: investigate how the disease brucellosis spreads among different herds of elk

5. Cathy Burson: Genetic Counselor
Cathy Burson, MA, helps scientists learn more about the genes that cause disease and how they are passed from generation to generation.

Video: Ms. Burson traces family medical histories and counsels the family about diseases caused by inherited genes.

Science Activities:
- Meet Cathy: explore your genetic features
- Alike and Different: discover what’s different and the same about you and your group
- Mating Game: meet mom and pop Smiley Face genomes and mate some genes to make a new baby
- What Sort? meet a cheek cell, say hello to chromosomes and complete a human chromosome chart
- Inside DNA: build a model gene using gumdrops and licorice and learn some secrets of DNA structures

1 Other kits include: Sea Otter Biologist with Dr. Brenda Ballachey, Pollen Detective with Dr. Peg Bolick, Parasite Sleuth with Dr. Judy Sakanari, and Urban Ecologist with Dr. Carmen Cid
2 CD-ROMs are part of every kit. They include the video, the science activities, supplemental activities and additional resources.
Dissemination

The field test of the classroom-based Wonderwise kits for nonformal educational purposes in the 10 consortium states actually initiated the dissemination by introducing the kits, albeit in unrevised form, directly to adult leaders. The project’s dissemination plan called for workshops to introduce Wonderwise 4-H in the nonformal educational setting; workshops ranged in length from one hour to several days. In many workshops, kits were distributed directly to adult leaders.

During the dissemination phase, 499 adult leaders participated in Wonderwise 4-H workshops led by the Museum’s Educator; another 582 participated in Wonderwise 4-H workshops led by 4-H staff in their state (Frerichs & Spiegel, 2003). Voluntary reports from adult leaders, workshop and conference enrollments, website visitors and downloads, and records on Wonderwise 4-H kit sales and broadcast rights sold indicated that over 2.5 million youth and 43,000 adults were potentially reached by Wonderwise 4-H in the 2002-2003 fiscal year (Spiegel, 2003). Kits are available from the Great Plains National Instructional Library (GPN) through the Wonderwise 4-H website: www.wonderwise.unl.edu.

Evaluation Plan

The evaluation plan for Wonderwise 4-H included multiple studies to examine project outcomes. It included (a) documenting the dissemination processes (Frerichs & Spiegel, 2003), (b) a case-study about the impact on youths’ understanding of science and their identification with the scientist role model (Acklie, 2003), and (c) an adult leaders’ web survey to identify kit uses and perceptions of how Wonderwise 4-H impacted youths’ view of science, scientists, and scientific work. As an extension of the classroom based Wonderwise (Diamond, Hochman, Gardner, Schenker, & Langan, 1996), the Wonderwise 4-H evaluation focused specifically on nonformal learning experiences and how youth incorporated the information and ideas into their thinking. This article reports on the adult leader web survey designed to explore the implementation processes and how adult leaders felt the subject matter influenced youths’ views of science, scientists, and scientific work.

Methods

Instrument. State 4-H representatives in the 10-state consortium and museum staff critiqued initial questions to clarify and help focus items to gather the most relevant data. The first draft included items used to evaluate the classroom-based Wonderwise kits. All items initially selected for the survey were pre-tested in a web-based format. The final survey consisted of eight open-ended items on specific uses of the Wonderwise 4-H kits, perceptions of impacts on youth including detailed examples of youth comments and behaviors, and opinions about the kits’ usability. Adult leader demographics included occupational position and gender.

Purposeful sample. The web survey gathered data from Wonderwise 4-H kit users, defined as individuals who used at least one activity from one kit with youth in an appropriate nonformal educational setting. Workshop records, conference participation records, and kits requests revealed 671 adult leaders with e-mail contact information; 450 e-mail addresses were workable and it was unclear if all remaining e-mail messages reached
their destination. Therefore, a hard copy of the instrument was also mailed to everyone for whom postal addresses were available; users were instructed to access the survey electronically to submit data. Follow-up e-mails and post card reminders were sent two weeks after the initial contact; 150 adult leaders fitting the criteria for the purposeful sample completed the survey.

**Data analysis.** The web-based survey was designed to drop data directly into an Access database as it was submitted. Responses were reviewed and emergent themes identified. Responses were then categorized by the emerging themes and coded accordingly. Codes and tallies were recorded on a spreadsheet. Because questions asked adult leaders to describe how *Wonderwise 4-H* affected “youths’ thoughts and feelings about science,” the results describe adult leader perceptions, not responses of the actual end user.

**Findings Related to *Wonderwise 4-H*’s Effectiveness**

**The Adult Leader and Ways They Used *Wonderwise 4-H***

**Adult leaders and educational settings in which kits were used.** There were 150 adult leaders who used *Wonderwise 4-H* and became part of data sample. They were classroom teachers, Extension employees including County Educators and State Specialists (i.e. campus faculty), Extension volunteers, and after-school program staff used at least one *Wonderwise 4-H* kit in learning environments for youth. They used the kits (a) in school classrooms, after school programs and other day care settings, spring break programs, and summer school youth programs, (b) at 4-H club meetings, day camps, and overnight camps, (c) at Girl scout meetings, summer library programs, and museum events, (d) for home schooling, and (e) for teacher in-service training.

**Wonderwise 4-H kits used.** All of the nine *Wonderwise 4-H* kits were used in the pilot testing phase. Genetic Counselor was only available a few months prior to the survey but it was still used by 12% of the adult leaders while each of the other eight kits was used by 20 to 40%. Many of the adult leaders in the sample used some of the individual kits multiple times and ¾ of the sample used two or more of the kits in their youth programming.

**End users.** *Wonderwise 4-H* kits were designed for 9- to 11-year-old youth. While 57% of the end users were estimated to be in the 9- to 11-year old category, adult leaders also used the kits for youth a couple of years younger (17%) or older (17%). One adult leader reported using the kits with 740 youth; the average number of end users per adult leader was 100.

**Perceptions of *Wonderwise 4-H*’s Impact on Youth**

Adult leader comments on how they felt *Wonderwise 4-H* impacted youth with whom they worked clustered into two strong theme areas:

- It brought “real science” into the youths’ lives by…
  …engaging them in actual scientific activities
  …increasing their understanding of what science is
  …broadening their view of who scientists are, what they do, and where they work.
- It introduced and encouraged youth to pursue science in their future by…
…helping them become more confident and capable at scientific endeavors 
…increasing their understanding of the possibilities of a science career 
…connecting them in a personal way with scientist role models.

Bringing real science into youths’ lives via engaging them in actual scientific activities. Overall, the activities and videos were described as being effective in engaging youth’s interest in real science through the scientific content. Adult leaders observed youth having fun with the activities, being interested in them, and getting engaged in the scientific topic. Typical adult leader comments include:

- [The activities] had a positive impact on the way the youth look at, and feel about science. 
  Extension Assistant, Nebraska

- In all of the programs we did using the Wonderwise Kits, the children were so absorbed in finding out the outcome of the activities. All of the children that participated in the programs really enjoyed the hands-on approach. 
  Americorp/Vista Volunteer, Michigan

- Many of my students were much more interested in learning the concepts of DNA, genetics, and the counseling field after watching the video and doing the hands on team activities. 
  County Extension Agent, Montana

- Many of youth reflected in their journals on what they saw in the video. Youth articulated that the things they were doing were just like what Carmen Cid does. Youth asked if they could meet more people like Carmen. They were impressed and wanted to get more connected with science. 
  Elementary Education After School Program Coordinator, Minnesota

Bringing real science into youths’ lives via increasing their understanding of what science is. The activities and videos gave youth an opportunity to experience real science by increasing their understanding of science. Many leaders noted how the videos showed real scientists in a variety of settings, and that many of the youth had not had this opportunity to see a scientist at work before. With the activities, the leaders frequently described the realistic, relevant nature of the hands-on experiences. Typical adult leader comments include:

- Videos give youth an opportunity to watch real life scientists in their surroundings, both professionally and outside of work, giving youth a background in how the scientist chose their profession. This helps link their real life story to careers in science. 
  4-H Program Assistant, Iowa

- The videos show scientists in their work environment. It provides students with a truer picture of what a scientist is and does. Students move away from the idea that science is done in a lab with a white lab coat and goggles. We had a few groans and yucks when the Vet Detective video showed the collection of fecal material but I didn't hear any ’I’m never doing that’ comments. 
  Classroom Teacher, Missouri

- I got the impression that the youth didn’t realize how scientists arrived at their conclusions…and that is by doing actual experiments, gathering facts, and going into the areas and fields and conducting interviews, etc. They are much more interested now in the science fields seeing that it is not just sitting a lab. 
  Adult Volunteer and Classroom Teacher, Iowa
• The youth have enjoyed the hands on activities and have been surprised at the variety of work scientists do. Most of them are interested in the work done in the field.  

4-H Program Assistant, Montana

Bringing real science into youths’ lives via broadening their view of who scientists are, what they do, and where they work. Wonderwise 4-H dispelled myths and created appropriate and accurate pictures about science for kids. The activities provided an opportunity to experience a different kind of scientific work, one that was more real and more meaningful than what they typically might do in science class. It opened up youths’ eyes to a wide variety of science fields and to what scientists really do. The videos were an important component in expanding youth’s view of science, scientists and even more broadly, their world. Typical adult leader comments include:

• Kids report they have a lot of fun learning about different types of science...a number of kids say they had no idea there were so many different types of science.  

Adult Volunteer, Iowa

• The videos give kids a first hand look at a scientist at work, and kids can see places and things beyond their own experience.  

State Specialist/Campus Faculty, Illinois

• Some of the girls told me they didn’t like science very much, but they said later they had a really good time with the Space Geologist activities and the experiments were fun, even though they were messy.  

Extension Associate, Nebraska

• The girls were amazed that there was a woman that was in the dirt and loving it.  

Classroom Teacher, North Dakota

Youth connecting with science via increased understandings of the possibilities of a career in science. Wonderwise 4-H introduced and/or encouraged some youth to think...
about the possibility of pursuing science in the future. The format of the kits, with a real scientist at the core of each kit, impacted the picture some youth had about their future interests. Many respondents specifically pointed out that the activities and videos affected the youth’s perceptions of a career in science or that youth indicated an interest in or intention of becoming a scientist. Typical adult leader comments include:

- They are able to see themselves doing science. The video allows them to see a scientist at work and also see that they are people. The activity book then lets them perform activities that mimic the scientist and learn science concepts in the process.
  
  State Specialist/Campus Faculty, Louisiana

- [Youth have] really started talking about doing different jobs when they grow up. The information coming from them is really knowledgeable since they have seen these kits.
  
  Adult Volunteer/Classroom Teacher, Minnesota

- Most remarkably, both boys and girls see the career field as something THEY can do. Typically, more boys than girls would see it this way in other programs with which I have worked.
  
  Adult Volunteer/Classroom Teacher, Nebraska

Youth connecting with science via connecting in a personal way with scientist role models. A significant portion of adult leaders commented on the youth connecting with the scientist or of the scientist serving as an important role model in the video. By seeing minority women who have families, and who are also scientists, youth recognized that they, too, could become scientists one day as well. Some of these women scientists grew up on farms, live in the Midwest, and look like the youth themselves—that helped connect with the youth. Typical adult leader comments include:

- The videos serve as a mentor. They make science REAL and ACHIEVABLE to girls and youth of color. The videos make science seem cool, and show that science is done by real people just like themselves—even people who grew up poor.
  
  Science Museum Educator, Minnesota

- As a result of this video I have one high school girl who volunteered at a veterinary office for several months and is now employed there. Although she has some learning disabilities she now believes that it is possible for her to become a veterinarian, which was her dream.
  
  Native American Education Coordinator, Oregon

Research With Youth Users Reinforces Adult Leader Perceptions

Acklie’s 2003 research with 25 youth users reinforces the adult leaders’ perceptions. The multiple method qualitative case study found immediate impacts after one exposure to one of the scientific topics (i.e., the use of one Wonderwise 4-H kit). Youth:

- Related to prior formal, informal, and nonformal science experiences as they made sense of and incorporated Wonderwise into their frame of reference.

- Saw the female scientist as someone they would like to be like; girls compared her to other role models already in their relationship network and Native Americans related to Tolani because of similarity in culture, even through tribal ties were different.

- Incorporated the scientific subject matter more strongly into their repertory of possible career opportunities; the experience nurtured increased self confidence in youths’ ability to do science, especially for the young girls, and reinforced a desire to choose a scientific career.
Kit Design

Adult leaders’ commented on the kit components. The science activities were the strongest, most used component, and the videos were also widely used and highly praised. The CD-ROMs were used the least, with only one-third of the adult leaders using them. For both the videos and the CD-ROMs, lack of equipment was given most frequently for non-use. However, those that used the CD-ROM found it to be a useful tool. Overall, adults who used the kits generally found them “easy to pick up and teach” (Extension Agent, Illinois). Typical adult leader comments include:

- *The activities give youth confidence and encouragement to learn more about science because the activities are hands-on and they understand what they are doing and the results.*  
  Extension Assistant, Nebraska

- *[The videos give] kids a first hand look at scientists at work, and kids can see places and things beyond their own experience.*  
  Extension Educator, Oklahoma

- *It allows the students to work on their own. The CD-ROM allowed my students to explore what really interested them.*  
  Classroom Teacher, North Dakota

Conclusions

*Wonderwise 4-H* serves as a model for how museums and 4-H can work together to improve nonformal science learning opportunities for youth. By collaborating on this project, 4-H youth and leaders were able to take advantage of a unique opportunity, and the museum was able to reach beyond its usual constituents. Using role models in this multimedia curriculum proved to be an effective means of improving youths’ attitudes about science through engaging activities and realistic videos that made science real and accessible. Dissemination of the project was extensive; it was achieved primarily through the 4-H networks that already existed in the partner states. The need for more effective and integrated science experiences for youth is great, and the success of this project suggests that opportunities for science learning can be enhanced through innovative collaboration of nonformal science partners.

References


Piburn, M. D. & Baker, D. R. (1993). If I were the teacher...qualitative study of attitude toward science. *Science Education 77*(4): 393-406.


