Making the Case Report – June 2002

Article Title: **Public Understanding of Science: Universities and Science Centers**

Author(s): Salmi, Hannu

Abstract: A survey of first and second year students at the University of Helsinki showed that 79.8% had visited Heureka Science Centre before beginning the university. Highest attendance was among students in the natural sciences (85%), social sciences (85.2%), and technology (84.5%). The author concludes that "the informal learning sources seem to have much stronger impact in academic career choices than has been recognised. Science centres have the potential for the universities as a motivational factor to create positive attitudes towards science and research among young people."

Source: Paper Presented at IMHE-OECD Seminar: Management of University Museums, September 2000. Abstract available at http://www.heureka.fi/en/mmain/heureka/index_ie.html

Keyword(s): Careers, students

Article Title**:** **The Math and Science Education of Women and Minorities: The California Perspective**

Author(s)**:** Kreinberg, Nancy

Abstract**:** The EQUALS Teacher Education Program, developed by the Lawrence Hall of Science, targets girls in grades 4 through 10. Where the program has been in effect for two or more years, the interest of young women in advanced mathematics and math-related careers has increased slowly but steadily. Students of SPACES, a part of the EQUALS program, "showed significant increases in knowledge of and interest in scientific careers and in spatial visualization and problem-solving skills in math."

Source: Paper presented at 3rd Annual AERA Northern California Regional Conference, University of California, Davis, CA, May 1, 1982. Abstract available at http://ericae.net/ED218114.htm

Keyword(s): Careers, teachers, equity

Article Title: **ASTC Sourcebook of Science Center Statistics 2001**

Author(s):

Abstract: Science centers contribute to the economic vitality of their communities. In the United States alone, 141 science centers reported operating expenses of $836 million for the year 2000. By extrapolation, estimated operating expenses for all U.S. science centers exceeded $1.38 billion. Only 34 percent of operating revenue came from public funds. Science centers also bring jobs to a community; 23,957 people worked at the 176 institutions reporting employment data.

Source: Washington, DC: Association of Science-Technology Centers, 2001.

Keyword(s): Economic impact

Article Title: **The Process of Education**

Author(s): Bruner, Jerome

Abstract: Learning theories support the value on hands-on approaches. Jean Piaget, Jerome Bruner and others stressed the importance of learning by doing, and of direct manipulation of objects. Bruner wrote: "The school boy learning physics is a physicist, and it is easier for him to learn physics behaving like a physicist than by doing something else."

Source: Cambridge: Harvard University Press, 1960.

Keyword(s): Experiential learning

Article Title: **The Constructivist Museum**

Author(s): Hein, George E.

Abstract: Constructivist learning theory has given additional support to the value of informal settings like museums, where people can engage in their own processes of inquiry in a "meaning-making" process. A museum that encourages constructivist thinking, according to Hein, builds "exhibits that allow visitors to draw their own conclusions about the meaning of the exhibition." He believes that "in order to make meaning of our experience, we need to be able to connect it with what we already know."

Source: Journal for Education in Museums, No. 16 (November 1995): 21-23. Available at http://www.gem.org.uk/hein.html

Keyword(s): Experiential learning, Informal learning environments

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Article Title: **Family Learning in Museums: The PISEC Perspective**

Author(s):

Abstract: A study conducted as part of the National Science Foundation-funded Philadelphia/Camden Informal Science Education Collaborative (PISEC) analyzed behavior and conversation in 128 family groups. The analysis showed that information family members were exchanging became richer and more complex during their visits. Their conclusion: "Families are learning in science museums."

Source: Philadelpia, PA: Philadelphia-Camden Informal Science Education Collaborative, 1998.

Keyword(s): Families

Article Title: **They're having fun - but are they learning anything?**

Author(s): Friedman, Alan J.

Abstract: Learning in informal settings like museums is different from classroom learning. While there is evidence that content learning does go on in museums, more important is learning in the affective domain - "creating those deep interests that motivate later learning both within and outside of the classroom." This

article summarizes some of the evidence and notes that while vocabulary acquisition may be easier to measure than this kind of learning, it may not reflect real understanding. "We still have a great deal to learn about learning, both inside and outside of the classroom," he writes. "But at least one fact is clear: learning and fun are not contradictory experiences."

Source: Forum on Education of the American Physical Society, Spring 2001. Reprinted with permission of the Parents League of New York, Inc. Available athttp://www.aps.org/units/fed/spring2001/friedman.html

Keyword(s): Informal learning environments

Article Title: **The Long-Term Impact of Interactive Exhibits**

Author(s): Stevenson, John

Abstract: John Stevenson, education officer at the Science Museum, London, interviewed 109 family groups immediately after their visits to the Launch Pad gallery, and then again 6 months later. He also asked them to complete questionnaires. He found "clear evidence of the long-term impact of Launch Pad on visitors. Several months after their visits, people are able to recall in vivid detail much of what happened. Visitors recall not only what they did with the exhibits but also how they felt and thought about them - and much of this recall is spontaneous." Most said their visit had been enjoyable, and 99% said they had talked about it with others, often family and friends.

Source: International Journal of Science Education, Vol.13, No.5 (1991): 521-531. Available at http://mlc.lrdc.pitt.edu/scripts/search_display.asp?Ref_ID=1929

Keyword(s): Memory

Article Title: **Memories as Indicators of the Impact of Museum Visits**

Author(s): McManus, Paulette M.

Abstract: Questionnaires mailed to casual, uncued visitors to the Birmingham Museum and Art Gallery an average of seven months after their visit showed that "people do clearly remember for long periods" their visits to museums, and that the memories vary widely and are very personal.

Source: Museum Management and Curatorship, Vol. 12 (1993): 367-380.

Keyword(s): Memory

Article Title: **Learning from Museums: Visitor Experiences and the Making of Meaning**

Author(s): Falk, John and Lynn D. Dierking

Abstract: Learning is "constructed over time as the individual moves through his sociocultural and physical world;

over time, meaning is built up, layer upon layer," and visits to science centers and museums become part of our store of long-term memories. Intrinsic motivation to learn is supported by enjoyment of science-related activities and positive memories of museum visits. As the authors note, "if they [museum-goers] did not derive deep intrinsic rewards from going to museums, they would not keep

Source: Walnut Creek, California: AltaMira Press, 2000.

Keyword(s): Memory, motivation

Article Title: **Motivation and Meaningful Science Learning in Informal Settings**

Author(s): Salmi, Hannu

Abstract: Research has documented increases in measures of motivation among students who visit a science center. Salmi studied three groups of junior high school students who visited Heureka, the Finnish Science Centre, near Helsinki once a month during the school year and compared them with students who did not visit. "Results indicate that the intrinsic motivation of learning difficulties and gifted groups grew during the project. The instrumental motivation of all the groups visiting the science centre grew, while the instrumental motivation of the control group decreased. Using programs, such as the linking of schools and science centres together in meaningful learning initiatives, teenager' decreasing motivation for learning can be minimised."

Source: Paper presented at the annual meeting of the National Association for Research in Science Teaching, 1998. Available at http://www.heureka.fi/en/main/heureka/index_ns.html

Keyword(s): Motivation, students

Article Title: **Science and Engineering Indicators 2002**

Author(s):

Abstract: "Sixty-six percent of those surveyed in 2001 reported that they had visited a science or technology museum at least once during the past year, the highest level of museum attendance ever recorded by the NSF survey. Museum attendance is positively related to formal education and attentiveness to S&T." That is the conclusion of the U.S. National Science Foundation, which has been tracking public use of science centers and museums since 1980 as part of its biannual Science and Engineering Indicators report. Of most interest is a section about "Where Americans Get Information About S & T."

Source: National Science Foundation, April 2002. Available at http://www.nsf.gov/sbe/srs/seind02/c7/c7h.htm

Keyword(s): Public understanding of science

Article Title: **Technically Speaking: Why all Americans Need to Know More About Technology**

Author(s):

Abstract: According to the National Academy of Engineering, "Museums and science centers, television, radio, newspapers, magazines, and other media comprise the informal education system, which offers citizens of all ages and backgrounds an opportunity to become engaged in a variety of issues related to technology. Research indicates that formal, school-based education is the primary contributor to a conceptual understanding in the sciences, but informal education also has a measurable impact on the acquisition of science knowledge (Miller 1998; 2001). Presumably, the same is true for technology."

Source: Committee of Technological Literacy; National Academy of Engineering; National Research Council, 2002. Available at http://books.nap.edu/books/0309082625/html

Keyword(s): Public understanding of science

Article Title: **Voyages of the Mind, Informal Learning**

Author(s): Ewing, Thomas S.

Abstract: NSF's Informal Science Education program, which provides support for science centers, defines informal education activities as "those in which learning is voluntary, self-directed, and motivated by intrinsic interests, curiosity, exploration, and imagination. Informal education is intended to stimulate lifelong learning."

Source: Synergy, a publication of the NSF Directorate for Education and Human Resources. January 1999. Available at http://www.ehr.nsf.gov/rec/pubs/newSYN/January1999/SYN6FEAT.HTM

Keyword(s): Public understanding of science

Article Title: **Science Centers for the 21st Century**

Author(s): Ucko, David

Abstract: Prepared for conference on the 21st Century Learning, this brief overview proposes that science centers have "an important role in our knowledge-based economy." Informal learning environments, by engaging visitors in ways that are enjoyable, help develop the capacity to go on learning.

Source: Institute for Museum and Library Services (IMLS), 2001. Available at http://www.imls.gov/whatsnew/21cl/21clucko.htm

Keyword(s): Public understanding of science

Article Title: **Civic Scientific Literacy: A Necessity in the 21st Century**

Author(s): Miller, Jon D.

Abstract: Nationwide studies of "civic scientific literacy" in the United States - "the level of understanding of science and technology needed to function as citizens in a modern industrial society"- indicate that "use of informal science education resources was positively related to civic scientific literacy," and in fact "second only to college-level science courses" in magnitude of its impact. The measure included going to science museums as well as use of science magazines, books, and Web sites and using the public

Source: FAS Public Interest Report: The Journal of the Federation of American Scientists, Vol.55, No.1(January/February 2002): 3-6.

Keyword(s): Public understanding of science

Article Title: **What Did You Learn outside of School Today? Using Structured Interviews to Document Home and Community Activities Related to Science and Technology**

Author(s): Korpan, Connie A., Gay L. Bisanz, Jeffrey Bisanz, and Conrad Boehme

Abstract: Through interviews with parents and school children in Edmonton, Alberta, the authors documented the "richness of science-related learning opportunities outside the home." Visits to a space and science center at least two or three times a year were reported by 66% of the parents.

Source: Science Education (Special Issue on Informal Science Education), Vol.81, No.6 (November 1997): 651-662.

Keyword(s): Public understanding of science, informal learning environments

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Article Title: **Multiple Perspectives on Children's Object-Centered Learning**

Author(s): Paris, Scott G.

Abstract: Most learning takes place in the context of meaningful activity and social interaction. Science centers provide rich, social environments of the kind that support learning. According to Scott Paris, "The authenticity of the artifacts and the affordances of the ILE [informal learning environment] foster the acquistion of knowledge because of the embeddedness of the desired knowledge and responses in the situation. The necessary embeddedness of learning and development in practical experiences is the centerpiece of theories of situated learning (Lave & Wegner, 1991) and apprencticeship (Rogoff, 1990)."

Source: National Science Foundation, 2000. Available at http://www.nsf.gov/sbe/tcw/events_000121w/events_000121w.pdf

Keyword(s): Sociocultural learning theory, informal learning environments

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Article Title: **Cognitive Apprenticeship: Making Thinking Visible**

Author(s): Collins, Allan, John Seely Brown, and Ann Holum

Abstract: The concept of learning as "cognitive apprenticeship" highlights the importance of a "community of practice" - "a learning environment in which the participants actively communicate about and engage in the skills involved in expertise... Such a community leads to a sense of ownership, characterized by personal investment and mutual dependency. It can't be forced, but it can be fostered by common projects and shared experiences." Science centers provide rich, social environments of the kind that support apprenticeship learning.

Source: American Educator, Vol.15, No.3 (Winter 1991): 6-11, 38-45.

Keyword(s): Sociocultural learning theory, informal learning environments

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Article Title: **Situated Cognition and the Culture of Learning**

Author(s): Brown, John Seely, Allan Collins, and Paul Duguid

Abstract: Science centers provide rich, social environments of the kind that support apprenticeship learning. According to these authors, "The term apprenticeship helps to emphasize the centrality of activity in learning and knowledge and highlights the inherently context-dependent, situated, and enculturating nature of learning." Like craft apprenticeship, "cognitive apprenticeship attempts to promote learning within the nexus of activity, tool, and culture," through "collaborative social interaction and the social construction of knowledge."

Source: Educational Researcher, Vol. 18, No.1 (January/February 1989): 32-42. Available at http://www.astc.org/resource/educator/situat.htm

Keyword(s): Sociocultural learning theory, informal learning environments

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Article Title: **A Framework for Organizing a Cumulative Research Agenda in Informal Learning Contexts**

Author(s): Schauble, Leona, Gaea Leinhardt, and Laura Martin

Abstract: Acknowledging limitations of research on learning in museum settings, the authors suggest three research themes, within an overall sociocultural framework: learning and learning environments; interpretation, meaning, and explanation; and identity, motivation, and interest. They advocate bringing research and theory into a "serious and sustained relationship with authentic practical problems."

Source: Journal of Museum Education, Vol. 22, No. 2/3 (1997): 3-8. Available at http://mlc.lrdc.pitt.edu/mlc_jme.pdf

Keyword(s): Sociocultural learning theory, informal learning environments

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Article Title: **Do children learn on field trips?**

Author(s): Gottfried, Jeffrey L.

Abstract: Jeff Gottfried observed children during visits to the Biolab at the Lawrence Hall of Science, then later asked them to draw and label a map of the Biolab and teach a biology lesson to another class that hadn't visited. During their field trips, he observed children exploring, performing experiments, and engaging in peer teaching. Later, he found that these children reported learning facts, concepts, and skills, and overcoming fear of animals.

Source: Curator, Vol.23, No.3 (1980): 165-174. Available at http://mlc.lrdc.pitt.edu/scripts/search_display.asp?Ref_ID=805

Keyword(s): Students

Article Title: **Analysis of the effect of a museum experience on the biology achievement of sixth graders**

Author(s): Wright, Emmett L.

Abstract: This study compared results of pre- and post-tests given to students who made a three-hour visit to the Kansas Health Museum and to a control group that studied the same material in the classroom, also for three hours. Students who visited the museum "showed superior achievement" on a test on recall of facts, relationships between different bodies of knowledge, and knowledge transfer.

Source: Journal of Research in Science Teaching, Vol.17, No.2 (1980): 99-104. Available at http://mlc.lrdc.pitt.edu/scripts/search_display.asp?Ref_ID=2138

Keyword(s): Students

Article Title: **What are the benefits of hands-on learning? How do I justify a hands-on approach?**

Author(s): Haury, David L. and Peter Rillero

Abstract: This review of research on activity-based science programs concluded that "the learning of various skills, science content, and mathematics are enhanced through hands-on science programs. Students in activity-based programs have exhibited increases in creativity, positive attitudes toward science, perception, logic development, communication skills, and reading readiness." Citing a 1982 analysis by Ted Bredderman of approximately 57 studies that compared activity-based programs with classrooms that used a traditional, textbook approach to science teaching, they summarize: "The most dramatic differences were found in science process skills where the students in activity-based programs performed 20 percentile units higher than the comparison groups."

Source: ERIC, 1994. Available at http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-2.htm

Keyword(s): Students, experiential learning

Article Title: **Messing About in Science**

Author(s): Hawkins, David

Abstract: In this essay, physicist David Hawkins wrote of his experience studying young children's learning in science as part of the Elementary Science Study. He stressed the importance of including in science education what he called "messing about" - "free and unguided exploratory work" in which "children are given materials and equipment - things - and are allowed to construct, test, probe, and experiment without superimposed questions or instructions."

Source: Reprinted in A New Place for Learning Science, by Sheila Grinell. Washington, DC: Association of Science-Technology Centers, 1992.

Keyword(s): Students, experiential learning

Article Title: **When Kids Do Science**

Author(s):

Abstract: Based on a research review, the article concludes that students in hands-on science programs do better than peers in tests of science process skills and have more positive attitudes toward science and science classes. Benefits in terms of content knowledge are not as clear. "But buried in these averages was a critically important fact: the benefits of hands-on science were greatest for disadvantaged students. On tests of both process skills and content learning, disadvantaged students made significantly bigger gains than their more advantaged peers."

Source: Harvard Education Letter, May/June 1990. Available at http://www.edletter.org/past/issues/1990-mj/kids.shtml

Keyword(s): Students, experiential learning, equity

Article Title: **Why Is Informal Education Important?**

Author(s): Roempler, Kimberly S.

Abstract: According to the author, ENC Associate Director of Instructional Resources, "Children are naturally curious and have a sense of wonder. They are constantly asking questions, using their senses to find out more about the world around them. Informal science learning environments such as science centers, museums, and zoos can provide students with unique, engaging, and captivating science experiences and opportunities. Combining formal experiences (schools), informal experiences (zoos, science centers, aquariums, etc.), and nonformal science experiences (4-H programs, Girl and Boy Scouts, etc.) is critical to improving their scientific literacy. "

Source: Eisenhower National Clearinghouse. Available at http://www.enc.org/topics/informaled/context/document.shtm?input=FOC-000779-about

Keyword(s): Students, informal learning environments

Article Title: **Hands-on biology: A museum-schools-university partnership for enhancing children's interest and learning in science**

Author(s): Paris, Scott G., Kirsten M. Yambor , and Becky Wai-Ling Packard

Abstract: A study of an out-of-school biology program offered by a museum-school-university partnership showed significant increases in children's interest in science and ability to solve problems. The program was a six-week curriculum for children in grades 3, 4, and 5, which culminated in a family night.

Source: Elementary School Journal, Vol.98, No.3 (January 1998): 267-288. Available at http://mlc.lrdc.pitt.edu/scripts/search_display.asp?Ref_ID=1522

Keyword(s): Students, informal learning environments

Article Title: **How People Learn: Brain, Mind, Experience, and School**

Author(s): Bransford, John D., Ann L. Brown, and Rodney R. Cocking, eds.

Abstract: Students spend more time out of school than in school. The family and other institutions outside the home can support learning. Among them are after-school programs, clubs, and museums. "Conversations and other interactions that occur around events of interest with trusted and skilled adult and child companions are especially powerful environments for children's learning." (p.136).

Source: Washington, DC: National Academy Press, 1999.

Keyword(s): Students, informal learning environments, sociocultural learning theory

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Article Title: **School Field Trips: Assessing Their Long-Term Impact**

Author(s): Falk, John H. and Lynn D. Dierking

Abstract: Field trips to museums are memorable events. Based on interviews of 128 children and adults, this study found that "even after many years, nearly 100% of the individuals interviewed could recall one or more things learned on the trip, the majority of which related to content/subject matter." The authors ask: "How many other one-day school experiences would measure up as well?"

Source: Curator, Vol. 40, No. 3 (September 1997): 211-218.

Keyword(s): Students, memory

Article Title: **Review of Selected References from Literature Search on Field Trips/School Group Visits to Museums**

Author(s): Bailey, Elsa

Abstract: Citing over 20 studies, Bailey touches on the various theories surrounding the value of school field trips and the role of museums as educational tools. She also says, "The stimulation to curiosity, the special experiences with real objects and phenomena that museums offer, and their influence on attitudes toward science and other areas of knowledge make them unique learning environments for students."

Source: Washington, DC: Association of Science-Technology Centers, 1999. Available at http://www.astc.org/resource/education/ftrips.htm

Keyword(s): Students, motivation

Article Title: **ASTC Sourcebook of Science Center Statistics 2001**

Author(s):

Abstract: Science centers work directly with students through school outreach programs and field trips, reaching an estimated 29 million children every year. In the United States, 91% of science centers responding to an ASTC survey offer field trips to school groups. Science centers also support schools by providing curriculum materials and science kits. Workshops for school teachers are offered by 83% of science centers worldwide responding to the survey; the 107 U.S. institutions that provided this data served 105,819 teachers through workshops and institutes in 1999.

Source: Washington, DC: Association of Science-Technology Centers, 2001.

Keyword(s): Students, teachers

Article Title: **An Invisible Infrastructure: Institutions of Informal Science Education, Volumes 1 and 2**

Author(s): Inverness Research Associates

Abstract: A 1994 study supported by the National Science Foundation documented a wide range of services provided by teachers and students by informal science education institutions - from teacher internships and curriculum development to outreach programs and field trips. Among the institutions that were part of this survey, 49% had formal, contractual agreements with schools, and 53% with school districts. The authors concluded that informal, science-rich institutions formed an "invisible infrastructure" supporting science education in the United States.

Source: Washington, DC: Association of Science-Technology Centers, 1996.

Keyword(s): Students, teachers, informal learning environments

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Article Title: **Preparing Tomorrow's Teachers: Preservice Partnerships between Science Museums and Colleges**

Author(s): Middlebrooks, Sally

Abstract: Science centers enrich the preparation of future teachers. A 1998 study, based on surveys and in-depth interviews, showed that "in small but significant ways, science museums are contributing to the quality of science teaching in tomorrow's classrooms. Science museums not only complement the preparation of tomorrow's teachers, they enhance and improve that preparation."

Source: Washington, DC: Association of Science-Technology Centers, 1999.

Keyword(s): Teachers

Article Title: **On-Site Science: Why Museums, Zoos, and Other Informal Classrooms Need to Be a Bigger Part of the Reform Equation**

Author(s): Bartels, Dennis M.

Abstract: "As few other educational settings could, the museum's environment is able to help teachers move from a third-person relationship with science - 'science that other people do' - to a first-person relationship: science that they can do, and, in turn, can help their students do." Bartels was writing about the Exploratorium, which during the previous 20 years had provided in-depth professional development opportunities for nearly 4,000 elementary and secondary school educators. In 2001, the San Francisco museum was providing 100,000 hours of teacher professional development a year, with an impact on an estimated 345,000 students.

Source: Education Week, September 19, 2001: 45.

Keyword(s): Teachers, students, informal learning environments

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Article Title: **Influences reported by adolescent museum demonstrators in the areas of communication skills, self-image and approach to science**

Author(s): Larsen, J.I.

Abstract: Surveys and interviews with high school students participating in the three-year Lab Rats program at the Cincinnati Museum of Natural History documented positive outcomes, including self-reports of improved communication skills. Girls were likelier to report more increases in awareness of science and in problem-solving skills. Both girls and boys reported feeling more self-confident.

Source: Unpublished doctoral dissertation, 1994. Available at http://mlc.lrdc.pitt.edu/scripts/search_display.asp?Ref_ID=1179

Keyword(s): Youth

Article Title: **YouthALIVE! From Enrichment to Employment: The YouthALIVE! Experience**

Author(s):

Abstract: More than 7,000 young people ages 10-17 participated in programs at science centers and museums through the 1991-1999 YouthALIVE! Initiative. Focus groups conducted by COSMOS Corporation showed that "youth learned appropriate ways to interact, not only with their peers but with people of all ages, genders, and ethnicities. Skills such as speaking to strangers, listening, teaching and instructing others, learning how to change the intonation of their voice for different occasions, and demonstrating patience were acquired on an ongoing basis throughout the programs."

Source: Washington, DC: Association of Science-Technology Centers, 2001.

Keyword(s): Youth, careers

Article Title: **National Science Partnership for Girl Scouts and Science Museums (NSP)**

Author(s): Campbell, Patricia B. and Karin Steinbrueck

Abstract: The National Science Partnership for Girls Scouts and Science Museums (NSP), funded largely by the National Science Foundation, was launched in 1992 to address concerns about science literacy in girls. The program, led by Girl Scouts of the U.S.A. and The Franklin Institute Science Museum, pairs local Girl Scout Councils with science centers, museums, and in some cases colleges or universities, to provide Scout leaders with training and familiarize them with science concepts and resources. The NSP reported that girls had more positive attitudes toward science after using the resources, and that Scout leaders increased their confidence level in doing science-related activities with their troops.

Source: Striving for Gender Equity: National Programs to Increase Student Engagement with Math and Science. New York: Collaboration for Equity between American Association for the Advancement of Science and Educational Development Center, 1996.

Keyword(s): Youth, motivation, equity