THE PIPELINE

Igniting Girls' Interest in Science

A partnership between university and Girl Scouts engaged young girls' interests in chemistry.

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Girls' interest, participation, and achievement in science decline as they advance in grade levels (*1*). For example, in fourth grade, the number of girls and boys who like math and science is about the same, but by eighth grade, twice as many boys as girls show an interest in these subjects (*2*). As the career expectations of eighth-grade students affect actual career outcomes (*3*), this interest deficit among girls may contribute to the continuing gender gap in science, particularly in terms of labor market outcomes (*4*).

Informal out-of-school programs have been shown to increase girls' interest and participation in science (*5*–*7*). Successful programs incorporate hands-on activities, role models, an emphasis on practical applications, and practices that promote equitable learning environments for girls (*6*, *8*) (table S1). Although the research is mixed, single-sex programs can provide a supportive learning environment for girls (*6*). Unfortunately, girls have fewer out-of-school science experiences than boys (*9*, *10*), a difference that may account for their lowered interest in school science courses (*9*, *11*). Additionally, girls' (and boys') participation in such programs dwindle during the transition from elementary to middle school, just as girls' interest in science wanes (*12*).

Program Overview

"Magic of Chemistry" was created to ignite interest in science among girls during this critical transition period (*13*) (see figure, right). The program is sponsored by the University of Missouri in partnership with the Girl Scouts–Heart of Missouri Council (*8*). The program has served more than 2500 girls over the past 10 years.

Each year, two identical Saturday workshops for 200 Junior Girl Scouts are organized in conjunction with National Chemistry and National Girl Scout weeks. Three different workshops rotate annually: Case of the Unsigned Letter, Fun with Polymers, and Chemistry of Color (*8*). Each utilizes American Chemical Society materials that reflect National Science Education Standards (*14*–*17*), specifically Standard A: Science as Inquiry. Workshops provide specific questions and data collection protocols to guide investigations. The girls formulate explanations from evidence, connect explanations to scientific knowledge, and communicate and justify their explanations (*18*).

Members of Troop 511 make "incrediblobs" in the Magic of Chemistry program.

During the 6-hour day, small groups rotate through experiments. Each girl is provided materials at an individual station, as well as a scientific notebook with questions and protocols. The notebook facilitates continuity in learning, and demonstrations related to each experiment reinforce scientific concepts. At each experiment's end, the girls discuss results and formulate a conclusion as a group.

Even though the overall program reflects best practices (*6*) (table S1), the story line that weaves each investigation together into a cohesive unit sets Magic of Chemistry apart from other informal science programs that rely on a series of disconnected experiments. The narrative comes to life with the assistance of highly trained volunteers including professional scientists who have the ability to help girls see the relevance of science to everyday life. The presence of prepared and qualified staff with sufficient knowledge of science is also important to the success of informal science programs (*6*).

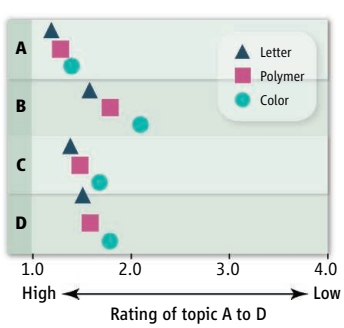
Program Assessment

Participants from 10 workshops from 1999 to 2006 completed postworkshop evaluations, rating the workshop on four indicators (*19*). Six of the 10 program evaluations included questions about college and science interest. Responses were tabulated and percentages calculated based on the total number of completed evaluations.

Open-ended questions asked participants to identify what they learned and liked about the workshop. Responses were analyzed using N-Vivo qualitative data analysis software (QSR International), and codes assigned using low-inference observation measures. Two separate blind analyses of the data were completed, and a high degree of interrater agreement (92%) was found. Codes were grouped into categories based on frequency, and patterns analyzed for themes.

Outcomes, Benefits, and Follow-Up

Workshops consistently received top ratings on all indicators (see chart, below). The perceived ease of each workshop is consistent with the level of difficulty of each investigation. Case of the Unsigned Letter contains single-step experiments; the other two workshops contain multistep experiments. When surveyed, adults' views mirrored those of the participants.



Summary of workshop evaluations. Level of A, quality; B, ease; C, interest; D, necessity. Data points represent the average score received on the evaluations (n = 1395 girls and n = 232 adults).

On average, 81% (range 66 to 88%) of participants wanted, after the workshops, to learn more about science and science careers (see chart, page 1622, top, and table S2). Participant interest levels may be linked to each workshop's perceived difficulty; for example, Chemistry of Color was

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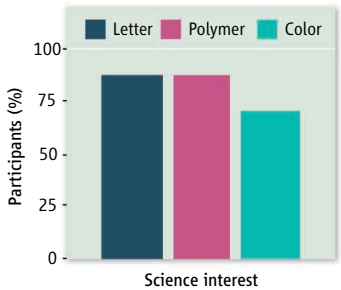
evaluated as the most difficult and also generated the lowest amount of interest of the three workshops (table S2).

Learning outcomes reflect the program's goal of teaching girls about science and its relevance to their daily lives. Although the majority of participants gave examples of activities and experiments (e.g., "doing tie-dye") as learning outcomes, they also cited scientific facts and concepts (e.g., "a dye can contain many different colors" and "carbon dioxide is heavier than air"), as well as real-world applications of science (e.g., "With DNA, you can find out if someone is family.") (see table, below, and tables S3 and S4). Beyond these primary outcomes, girls also noted learning laboratory techniques (e.g., "I learned how to do a soil analysis") and how to use scientific equipment, a need for girls that has been documented (*20*). Although not an explicit learning objective, laboratory safety was also a notable learning outcome.



Percentages of girls with interest in learning more about science and science careers (n = 911).

The "fun" aspects of workshops, the opportunity to learn new things, and social interaction with peers were all cited as things liked about the workshops (see table, below, and tables S3 and S5). These responses are frequently cited by youth as reasons for participating in informal learning programs (*12*). As such, we feel successful in having met our objective of creating a positive association with science.

Although important, fun alone is not enough. We also strive to instill in girls a lifelong desire for learning. The number of responses focused on the program's campus location is clear indication that this other primary objective has been met (see table, right, and tables S2 to S5). Besides being able to eat in the campus dining hall, girls liked being able to "see what college is like," "feeling more grown up," and interacting with college students. About 30% of respondents indicated that this was their first visit to a college campus (table S2).

Although encouraging, these results cannot tell us whether girls who participate in Magic of Chemistry maintain an interest in science. Evaluation of long-term effects is a challenge of informal programs (*20*). Because interest levels have been shown to increase the longer students participate in informal programs (*21*), some insight, albeit anecdotal, may be garnered from participation rates in Magic of Chemistry: About 29% of girls participated in more than one workshop; 11% participated in three (table S6). Furthermore, a continuing interest in science has been cited as a reason by former participants who later volunteer to help with the program (table S7). Other anecdotal support comes from parents and teachers who have witnessed girls displaying a more notable interest in science following participation. Of course, a longitudinal study of participants would provide better evidence of the program's effectiveness at inspiring a long-term interest in science.

Portability

Magic of Chemistry has been successfully adopted at three other institutions of higher education in Missouri and Kansas (*22*), and the workshops are being used as a science enrichment activity for a mixed-sex, public elementary school audience. Portability is facilitated by the use of program kits (*8*) and the 3-year workshop cycle. The only real restriction caused by adopting the Magic of Chemistry is the age group it addresses.

Conclusions

Magic of Chemistry educates young girls about science and, more important, encourages their interest in scientific discovery at a critical time in their educational development. Informal programs such as this one can help break down the walls between the formal education system and the students' real life, bringing context to one and insights to the other.

Response categories	Percent of responses
Learned	
Activities and experiments	60
Scientific facts and concepts	46
Laboratory techniques	41
Results of experiments	24
Understanding of scientific work	14
Real-world applications of science	10
Safety in the laboratory	5
Liked	
Food	52
Fun	25
Learning	25
Experiencing campus life	19
Social interaction with peers	19
Interacting with college students	10

Responses to open-ended questions. Girls were asked to respond to two questions: "What are two things you learned from the Magic of Chemistry activities?" and "What are three things you liked most about attending a special event at the University of Missouri?" (n = 967).

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