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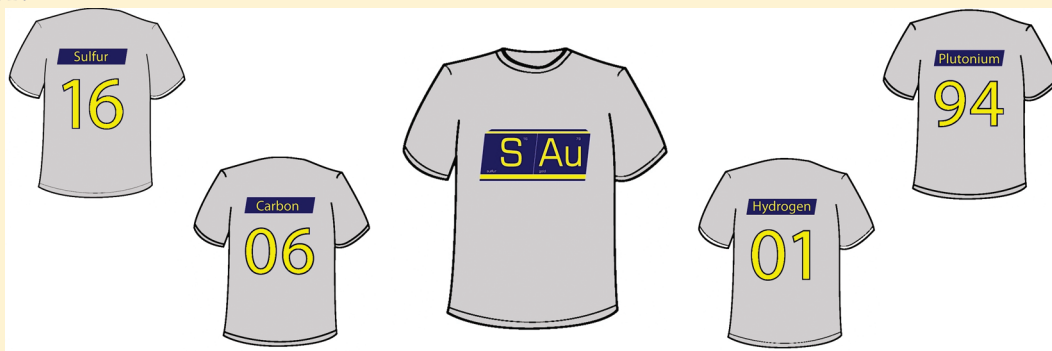
Adventures in Coaching Young Chemists

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S Supporting Information

ABSTRACT:



We believe that students should have opportunities—early and often—to learn about science and math activities in fun and recreational ways. As a result, we try to provide many science enrichment activities to the surrounding community. In doing so, we hope to inspire young students to become future scientists and mathematicians. Here we describe some annual science outreach events that we have hosted, share a few demonstrations and activities we have tried at these events, and discuss how we plan to connect our outreach in 2011 to the themes of the International Year of Chemistry.

KEYWORDS: Elementary/Middle School Science, General Public, Public Understanding/Outreach

On September 16, 2010, President Barack Obama announced Change the Equation, an expansion of the Educate to Innovate program, designed to inspire U.S. students to pursue degrees in science, technology, engineering and mathematics (STEM) and to improve American STEM education.¹ During his announcement, the President noted the mediocre achievement by American students in science and math:¹ “One assessment shows American 15 year olds ranked 21st in science and 25th in math when compared to their peers around the world”.

It seems a bit ironic to us that the United States is always near the top of the medal count during the Olympics, but our students lag behind in mathematics and science. Even President Obama remarked¹ “America doesn’t play for 2nd place, and we certainly don’t play for 25th”. Oddly enough, it may be that in this land of vast resources, American children do not have many opportunities to engage in STEM activities that stimulate and inspire. Consider the following letter we recently received from a parent:

I just received the flyers for the Halloween in the Science Lab event you’re organizing. I just wanted to say thank you for providing this type of opportunity. My son has participated in the Science Camp twice now and REALLY enjoys science. He’s not all that into sports, there aren’t very many [science] clubs available, etc. So to have these science opportunities available and to see him be so excited about them is very welcome. I will certainly be signing him up!

We receive similar letters often. While American elementary school students have boundless opportunities to participate on sports teams (Little League baseball, AYSO soccer, etc.), few grassroots programs exist that inspire children to pursue scientific and mathematic endeavors. However, chemical educators at all levels have the knowledge and resources to “coach” young students to pursue excellence in mathematics and science. Unfortunately, chemists at many academic institutions are reluctant to participate in outreach endeavors.² We therefore applaud the efforts of chemical educators and chemistry students who are involved in presenting science to the public, providing interesting, hands-on chemistry experiments for young people to explore (see, for example, refs 3–11). We are similarly motivated by a desire to interest elementary and middle school students to excel in mathematics and science. As a result, along with college students from our institution, we visit shopping centers, fairs, and places of worship several times a year to present active, hands-on math and science activities to K–8th grade students. We also hold an annual, weeklong summer science camp.

In this paper, we describe various science outreach events we organize, present some strategies we have used in these efforts, and discuss how we plan to connect our outreach in 2011 to the themes of the International Year of Chemistry (IYC).

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■ DESCRIPTION OF SCIENCE OUTREACH IN THE COMMUNITY

The Spring Arbor University (SAU) chemistry department participates in several annual outreach events: Math and Science Night, Halloween in the Science Lab,¹² Swim-o-Rama, and the Cougar Science Camp. We are also regularly invited to classrooms, learning fairs, and expos to present science experiments and demonstrations to students, and we accept these invitations regularly. During all of these events, we present chemistry demonstrations and hands-on activities to K–8th grade students. Math and Science Nights are held at an elementary school that is within walking distance from our campus; two of these events are held annually, one in October and the other in February. For Halloween in the Science Lab, K–6th grade students are invited to dress up in Halloween costumes and visit our campus to participate in activities in our laboratories. Students receive trick-or-treat candy upon completing experiments. During Swim-o-Rama, students participate in hands-on science activities after enjoying a swim in our campus pool. Perhaps the capstone of our community outreach is the Cougar Science Camp (Figure 1), which runs Monday through Friday during a single week in the summer. While most of the camp is geared toward chemistry, we integrate other areas of science into the camp activities as well. Each day at camp begins and ends with a chemistry show, during which several demonstrations centered on a particular theme are presented (Tables 1 and 2). At times, we have designed camp T-shirts that help to generate excitement in the themes chosen for a particular camp (Figure 2).

We decided to make a strong commitment to outreach efforts in 2004. Since this time, our outreach events have grown substantially in popularity on campus and within the community. The first year of camp the two coauthors guided eight students in grades 6–8 through two days of activities. The past three



Figure 1. This logo for the Cougar Science Camp was used on the camp T-shirt in 2006, and has been used on the camp brochure from 2006 to the present. Design by Brian Shaw, SAU art professor; reproduced with permission.

summers, 20–25 adults worked with 100 K–8th grade students. About 150 students attend each of the Math and Science Nights and the Halloween in the Science Lab, and usually 40 or so students attend Swim-o-Rama.

College Student Participation in Outreach

Our department has only two faculty members with a full time teaching load in chemistry. As a result, we need a substantial amount of help with the large number of young students that attend these events. Students in our General Chemistry I and II classes, of whom we require 5 h of community service as part of the coursework, provide the lion's share of this help. Students earn service hours in the laboratory by setting up and testing activities or "researching" new experiments to try with those attending Cougar Science Camp in the summer. In certain cases, devising new chemistry activities has led to publication.^{13,14} College students also earn service hours at the outreach events by presenting lessons to the elementary students, helping to set up and tear down experiments or just being present to help supervise young students. Service learning of this type seems to be quite a successful approach to scientific community outreach, and had been employed at a number of institutions.^{7–11} At SAU, many students work hours beyond the required 5 h, and education majors particularly appreciate the chance to teach science concepts to elementary and middle school students.

Parent or Guardian Participation in Outreach

Unfortunately, very few SAU students are on our campus in the summer when the Cougar Science Camp takes place. Thus, ensuring enough workers to manage all the campers has always been a big challenge. We finally solved this problem by offering free tuition to campers of a parent or guardian volunteer who works as a camp counselor. We routinely have 15–20 parents or guardians (many of whom are non-STEM SAU faculty members) who choose this option. These parents often comment on how much science they learn during the camp:

As a Parent Volunteer I learned as much as my children and felt like a child again during this week long expedition into the exciting world of Science. Dr. K and his staff create an exciting atmosphere for learning and participation and by the end of the week we felt part of their Team. I would recommend this experience to any parent who is thinking of new ways to engage, challenge and build memorable experience with their children!

Some parents even get involved in activities and demonstrations, teaching us a thing or two. For example, in 2009 a parent taught the campers how to assemble marshmallow guns from PVC pipe and fittings. We had great fun with a marshmallow war at snack time that day.

Often, parent volunteers assist leaders by aiding campers when they need help during activities. To make these activities more

Table 1. Daily Schedule for the Cougar Science Camp

Time	Activity
8:30–9:00 a.m.	Chemistry demonstration show
9:00–10:15 a.m.	Group time: Students are split by grade (K–2nd; 3rd–5th; 6th–8th)
10:15–10:45 a.m.	Snack (outdoors, weather permitting)
10:45–11:45 a.m.	Group time: Students are split by grade (K–2nd; 3rd–5th; 6th–8th)
11:45–12:00 pm	Clean up
12:00–12:30 pm	Chemistry demonstration show

Table 2. Themes and Daily Topics Presented (2008–2010) or Planned (2011) for the Cougar Science Camp^a

Year	Overall Camp Theme	Monday Topic	Tuesday Topic	Wednesday Topic	Thursday Topic	Friday Topic
2008	Great scientists	Mendeleev (periodic table)	Bohr (atoms)	Curie (elements)	Einstein (light)	Chemical reactions
2009	Elements	Hydrogen (gases)	Carbon (organic)	Sulfur (nonmetals)	Gold (metals)	Plutonium (energy)
2010	Chemistry of the solar system	Sun	Inner planets	Earth and Moon	Gas giants	Space exploration
2011	International Year of Chemistry	Environment	Materials	Energy	Health	IYC Celebration

^a No overall camp theme was employed in 2005–2007.



Figure 2. Campers chose from four different T-shirts with names of different scientists on the back. In 2009, students chose from five different T-shirts with names and numbers of different elements on the back of the shirt: S, C, H, Pu, and Au. (N.B. The logo in the front view of the shirt in the abstract figure shows the S and Au symbols.) Scientist T-shirt designs by SAU art student Stephen Thomas; element T-shirt designs by SAU art student Derrick Robbins; both reproduced with permission.

manageable, the campers are placed in one of three groups based on their grade levels (Table 1), for different activities each day. Each group participates in 4–5 hands-on activities each day, which translates into 60–75 activities we need to plan for the entire week. While we try to plan different activities each year, some are so popular that we do them at every camp (Table 3). For the water rocket activity, students are encouraged to build rocket designs at home and bring their test models to camp where they are launched throughout the day. (We assign an adult worker to set up five rocket launchers and supervise the launches.) Campers construct model rockets using 2-L soda bottles and simple materials, and the goal is to have the rockets soar to the top of SAU's clock tower on campus (Figure 3). Some campers become so interested in this project that they spend all day at camp designing and launching test rockets.

Practicing and Prospective Teacher Involvement in Outreach

To help plan the science camp activities, we hire three camp co-directors who are in charge of the development and presentation of all the scientific topics for a particular age group. These paid positions are announced to SAU students and the surrounding community at the beginning of the spring semester. We interview candidates for these positions, in part to communicate our expectations to prospective co-directors. Often there is intense interest among STEM teacher education students who rightly perceive the opportunity as an excellent way to build their résumé. Other times, experienced teachers have been attracted to the positions to improve their résumés or to receive graduate credit in education.²⁰ The co-directors selected work together with the chemistry faculty for an entire week before the camp to discuss scientific topics to be covered at camp and to plan activities. We have hired local teachers, local parents, education majors, and chemistry majors as camp co-directors.



Figure 3. Successful water rocket launch. The arrow indicates the position of the rocket. (Photograph by one of the authors, B.W.B.).

Faculty Involvement from Other Disciplines

As interest in the camp has grown, SAU professors from other STEM disciplines have joined forces with the camp. These professors generally work with students who choose to focus for an hour each day on a special project. Last year, a mathematics professor guided students through statistics problems using M&M candies. Computer science faculty taught campers to program Lego robots to perform simple tasks. An SAU physics professor worked with students to generate an outdoor scale model of the solar system in which the Sun was the size of a softball, and Pluto was about a half mile away; it took 20 min to walk from the Sun to Pluto and back!

CONNECTING OUTREACH TO IYC

Activities at this year's science camp will focus on the themes of the IYC (Table 4). The daily demonstration shows and activities will highlight how chemistry connects to the environment, energy, materials, and health. We have several special activities planned for the IYC celebration on the last day of camp. For the demonstration show that day, we are simply going to perform some of our camper's favorite demonstrations just to celebrate chemistry itself. For snack, we will have a periodic table of 112 cupcakes arranged in the appropriate manner; each cupcake will have a certain element's symbol decorated in icing on top. Finally, we will have a periodic table bee, a competition in which students will have 3 min to state from memory as many elements as they can in order of atomic number.

We also plan on linking this year's Halloween in the Science Lab event to IYC as well. Prior to elementary and middle school students doing experiments in the lab, we will hold a chemistry show that focuses on the IYC theme of energy, a topic which of course lends itself to many interesting demonstrations of chemical reactions. In one of the activity rooms, students will build

Table 3. Sample of Popular Activities at Cougar Science Camp

Activity	Description
Gold pennies	Pennies are coated with zinc: when heated, the zinc and copper from the penny combine to form a brass alloy ¹⁵
Chromatography T-shirts	Students use chromatographic principles to decorate T-shirts ¹⁶
Liquid N ₂ ice cream	Ice cream is made using liquid nitrogen to freeze an ice cream mixture ¹⁷
Water rockets	Campers construct rockets using 2-L beverage bottles and other simple materials—The rockets are launched using water and air pressure ¹⁸
Slime making	Polyvinyl alcohol and borax solutions are mixed to form a slimy, cross-linked polymer ¹⁹

Table 4. Sample Demonstrations and Activities Linking 2011 Cougar Science Camp to IYC Themes

Day	Focus	Sample Demonstration	Sample Activities
1	Environment	Acid–base chemistry ²¹	Acid rain ²²
2	Energy	Exploding H ₂ balloons ²³	Hydrogen powered rockets; ²⁴ Model hydrogen fuel cell cars
3	Materials	Properties of polymers	Slime-making; ¹⁹ Fire gel; ¹³ Bouncing ball breakdown ¹⁴
4	Health	Howling gummy bear ²⁵	Estimation of calories in foods ²⁶
5	IYC celebration	Elephant toothpaste ²⁷	Periodic table bee

representative elemental squares of the periodic table using Lego building blocks. We plan on building the entire periodic table out of Lego blocks in this fashion,²⁸ and to hang the finished product in one of our chemistry laboratories to showcase at future outreach events.

CONCLUSION

Perhaps one reason why U.S. athletes, but not U.S. students, are among the best in the world is because we as citizens spend more time encouraging our young people to win a championship in sports (which is a valuable endeavor) than we do inspiring them to excel in mathematics and science. In addition, in many areas of the country few opportunities exist for elementary and middle school students to participate in extracurricular science and math activities. Therefore, it is our opinion that chemists and chemical educators everywhere should strongly consider acting as local “science coaches”, investing in the future of science education through regular public outreach. Outreach endeavors have the potential to provide a nexus for students, parents, community volunteers, and faculty to meet on common ground for the purpose of excellence in science education. The synergistic learning community of prospective teachers, experienced teachers, parents, campers, and faculty at the Cougar Science Camp helps to generate long-term buzz about science. Science faculty members from SAU are often greeted in the community by our science camp nicknames of “Hydrocarbon Man”, “Dr. Atomic”, and “Professor Protein”. Aside from a fun way to greet friends, this type of recognition provides our community with an accessible introduction to science practitioners, and perhaps gives young scientists a “coach” or two of their own.

ASSOCIATED CONTENT

Supporting Information

Additional logo and T-shirt images. This material is available via the Internet at <http://pubs.acs.org>.

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(28) We would greatly appreciate donations of your unwanted 1×1 (Design ID 3005), 2×2 (Design ID 3003), and 2×4 (Design ID 3001) Lego blocks to support this project. Red, yellow, green, blue, brown, black, and white blocks are desired. Contact the corresponding author for more information.