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Collaboration and Near-Peer Mentoring as a Platform for Sustainable Science Education Outreach

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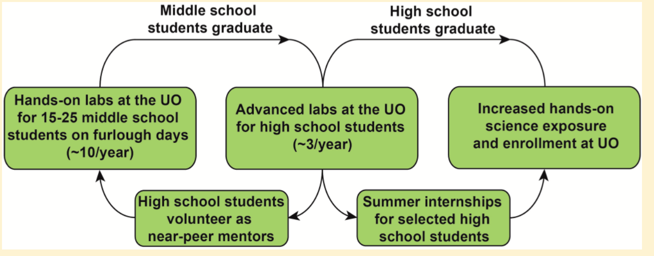
Supporting Information

ABSTRACT: Decreased funding for middle and high school education has resulted in reduced classroom time, which, when coupled with an increased focus on standardized testing, has decreased the exposure of many middle school students to hands-on science education. To help address these challenges, we developed an integrated outreach program, spanning grades 6−12, designed to engage students by bringing students to the University of Oregon to perform hands-on laboratory experiments. Initially developed to supplement science education lost to state-mandated furlough days, the programmatic design can be applied readily in other contexts including afterschool, weekend, or summer programs. The outreach activities and scaffolding rely heavily on near-peer mentoring, which provides a visible pathway for younger students to envision themselves as future scientists while also providing mentoring and leadership opportunities for high school, undergraduate, and graduate students. The use of near-peer mentoring is also critically important for the program's sustainability because it enables a more efficient allocation of graduate student and faculty time. In the first 2.5 years, over 450 middle school students have participated in the program and student feedback shows that students are engaged and excited about the outreach activities.



KEYWORDS: *Elementary/Middle School Science, General Public, Curriculum, Public Understanding/Outreach, Hands-On Learning/Manipulatives*

■ INTRODUCTION

Outreach activities by active university researchers that engage middle and high school students[1−6] have become an important contribution to the development of the national science, technology, engineering, and mathematics (STEM) workforce.[7−10] Despite the positive impact of faculty outreach, such activities often consist of one-time or once a year events[11] that do not provide sustained motivation for individual students due to limitations on faculty time.[12] Providing a scaffold in which students regularly participate in STEM outreach activities enables students to engage in informal science education outside of a classroom setting while also providing students with mentors/role-models that demonstrate the accessibility of careers in STEM fields.

Compounding the contemporary challenges of STEM education, the recent economic downturn decreased the available funding for primary and secondary education and led to state-mandated teacher furlough days in Oregon.[13−15] This budgetary reduction resulted in decreased supply budgets and increased class size, both of which were damaging to science education. When combined with the increased emphasis on standardized testing, the ability of teachers to offer laboratory-based hands-on science education, which is both time and resource intensive, has been diminished significantly. The reduced exposure to science for middle school students comes at an important age in which positive STEM experiences have long-lasting impacts on future scientific aspirations.[16,17] Reduced hands-on science education at a young age not only decreases students' general appreciation of science,[9] but also limits the development of students' self-image as a scientist.

Motivated by these challenges, we report here the development of an integrated outreach program, spanning grades 6−12, designed to engage students through hands-on activities spaced throughout the school year and to allow them to interact directly with practicing scientists, including graduate students and professors.[18,19] The outreach activities rely heavily on hierarchical near-peer mentoring,[20] which may help the younger students envision themselves as future scientists (e.g., as described by "possible selves" theory[21]) while also providing mentoring and leadership opportunities for high school, undergraduate, and graduate students. Mentors also gain valuable experience in effectively communicating scientific principles and enthusiasm to a diverse audience. The use of near-peer mentoring[22,23] is also critical for program sustainability as it enables efficient allocation of graduate-student and faculty time and thus increased depth and frequency of the outreach. The outreach program was initially designed in the Department of Chemistry and Biochemistry at the University of Oregon (UO) to supplement decreased science education due to state-mandated middle- and high-school furlough days (2010−2013). Thus, the

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program augments and enhances science education by filling the gap created by state budget reductions in a sustainable way. Additionally, the program has been recently adapted to provide STEM education on early release days, thus highlighting the adaptability of the program for other settings, including afterschool, weekend, and summer programs.

■ PROGRAM DESIGN

In designing a sustainable outreach program, our goal was to ensure that all participants, including middle/high school participants and staff, undergraduate students, graduate students, and university faculty, felt connected to the program and could efficiently contribute in various capacities. To identify key areas of need and thus maximize the impact of the program, we first met with local school teachers and administrators to develop an outreach plan. From these discussions, four main points surfaced: (1) budget cuts have significantly reduced the number of classroom hours available to teachers to teach mandated material; (2) implementing labs is a major challenge due to a lack of classroom time and lack of available funding for supplies; (3) state-mandated testing makes deviation from standard curricula during class time difficult; and (4) few students could see themselves as scientists or, in many cases, even as future college students due to a lack of STEM-related role models in their communities. Based on these points, we hypothesized that UO science faculty could best impact local middle school science education by developing and running laboratory-based learning activities at the UO on furlough and other no-school days. By hosting the labs at the UO on days that classes would have otherwise been canceled or shortened, time spent on science education is augmented rather than reduced as valuable classroom time is not sacrificed to participate in the outreach lab events. Holding the activities at the UO allows for integration of lab and campus tours into the outreach events, which furthers the goal of fostering a school-to-college identity, in which primary school students can envision themselves as college students or even college graduates. By meeting with local educators prior to developing the program, we also became aware of existing afterschool programs and staff that were in need of quality science-based content and suitable mentors for implementing new activities. Designing our outreach effort in partnership with existing afterschool program staff from the beginning allowed us to capitalize on existing expertise in recruiting and managing middle school students and thus focus our effort on maximizing program impact and scalability by efficiently using faculty time and resources. On the basis of the above, we reduced the program elements to the following challenges, objectives, and intended outcomes:

Challenges

- Decreased classroom contact hours due to mandated furloughs or budget constraints
- Limited resources to purchase laboratory supplies for science labs
- Lack of STEM role models and connections to college

Objectives

- To provide high-quality, hands-on science education for local middle and high school students
- To create a framework for students to envision themselves as learners from middle school through college

Outcomes

- Enhanced school-to-college identity and community awareness of science
- Development of a scalable middle-school-to-college science pathway
- Improved science-oriented student self-image

One primary challenge in designing the program was maximizing its flexibility to allow for coordination between middle school, high school, and university schedules. To meet these goals, we designed the program so that each outreach activity was led by 2−3 graduate students that design the curricula in collaboration with faculty, with other graduate, undergraduate, and high-school students working alongside and mentoring the middle school students during the activities. Additionally, we recruited other student-led groups on campus, including the Women in Graduate Science and Women in Computer Science, to develop and run modules, thus adding flexibility to the program by allowing it to function on days when chemistry graduate students were not available while also broadening programmatic participation. Furthermore, this design provides a network spanning from high school to graduate school that gives students at all levels mentoring experiences. The graduate students who lead the activities are associated with a UO research lab and typically develop modules (see the Supporting Information for a general description of the current outreach activities) connected to their thesis research, such as the "Electrochemistry and Batteries" module, which was developed by students whose graduate research focuses on redox chemistry. Designing modules around contemporary research themes exposes middle school students to more advanced scientific topics and emphasizes that the involved graduate students are in fact practicing scientists. Additionally, many of the participating graduate students are interested in science education and outreach experience furthers their professional goals.[24] Most graduate advisors are supportive of these activities because they efficiently further the professional development of the mentors in the program and also provide valuable community science education. Additionally, some graduate students have used the program as a way to strengthen the "broader impacts" components of various fellowship or grant applications.

To recruit high-school volunteers, we partnered with the Advanced Placement (AP) chemistry class of a local high school into which the middle school we targeted in the outreach activity feeds. In addition to receiving community service hours (which are required for graduation) for this outreach time, the high school students also gain leadership experience.[25] To provide further educational benefit to the high school students, the entire AP chemistry class visits the UO twice per year outside of class time to perform advanced laboratory experiments in UO teaching or research labs. The students are exposed to state-of-the-art instrumentation which otherwise would not be accessible to high school laboratories. These labs are primarily run by undergraduate and graduate students, thus furthering the connection of advanced high school students interested in the sciences with college mentors and STEM role models. Additionally, high school students from the program apply for UO summer research internships (two high school students have completed such summer internships so far), thus helping to launch their STEM careers. The long-term vision is that middle school students who participate in the program return as near-peer mentors when they are in high school (as several have done already), and eventually as research interns (Figure 1). Taken together, the program illuminates a seamless pathway for middle school

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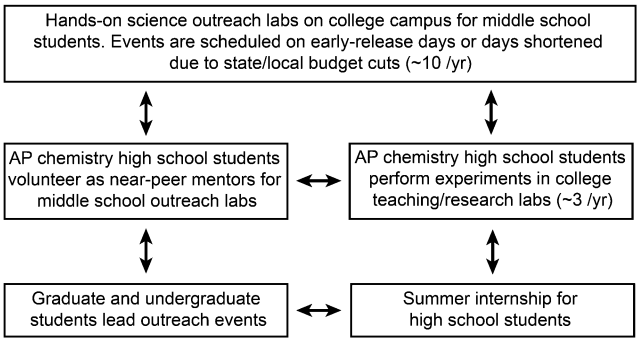

Figure 1. Schematic summary of the designed outreach program that includes local middle and high school students in an integrated system of lab experiments and near-peer mentoring.

students, with mentors at all levels with whom they can relate, that allows the students to envision themselves as scientists and take the steps necessary to be successful on that path.

LAB MODULES

Lab modules used for the outreach events consist of a combination of newly designed, repurposed, and existing labs that were modified to meet space, time, and audience requirements.[26−30] Each lab module was designed to contain different activities centered on a common theme. Most labs focus on concepts that tie fundamental scientific principles with "real-world" activities to increase student interest and to clearly communicate the important role of science in everyday life. Additionally, lab modules were designed or modified by graduate students and faculty to be as safe as possible, often using household goods, rather than laboratory-grade chemicals, to demonstrate chemical concepts. This design allowed the modules to operate in almost any available space, an important requirement for any program on a busy college campus. Finally, lab modules were designed or chosen such that an initial investment could purchase supplies or minor equipment, but that each successive module run was inexpensive or cost-free. Most of the modules feature a short packet or "lab notebook" that helps to guide middle school students through the experiments and reinforces traditional science practices such as data or observation recording.[11] The overall design of these outreach modules dovetails with many of the strands for informal science education as described by the Center for Advancement of Informal Science Education, including "Sparking and Developing Interest and Excitement" by connecting each module topic to the students' real world experiences and "Identifying with the Scientific Enterprise" by encouraging students to view themselves as scientists throughout the program.[31−33]

To help standardize activities for the participants and volunteers, each lab module follows the same general format. Middle school students meet at their school and then travel to the UO by bus with the middle school coordinator. A graduate student leader provides a short (~15 min) presentation about the activities in the lab, including safety aspects and how the scientific concepts from the lab relate to the "real world." Middle school students are then divided into teams of six to eight (with science-themed team names), each with one high school near-peer and/or graduate student mentor (20−30 students total). Midway through the activities, students break for a group lunch (depending on the time of the activity), a campus tour, or a tour of the science facilities at the UO. The lunch break also provides time for informal interactions between students at all levels. The middle school after-school program coordinator helps to manage the students and provide consistent structure for enforcing discipline. The partnership with someone experienced in the supervision of middle school students, such as a school coordinator, teacher, other school official, or volunteer, was found to be important for the effective implementation of the activities.

After completing the labs, there is a short interactive presentation summarizing what students learned during the activities, followed by time to fill out evaluations (vide infra). The evaluations provide useful information on what students experienced, what topics they would like to learn about, and feedback on the specific lab activities. After completion of the activities, the middle school coordinator takes the students back to school. For high school labs, the same general format is used with the students divided into groups of 6−8, with one graduate student mentor per group. Listed below are lab modules that have been used in the program thus far:

Middle School Lab Activities:

- The Chemistry of Color
- Acid−Base Chemistry
- The Inner Workings of Electronic Devices and Solar Cells
- The Science of Microscopy
- Phases of Matter, Chemical Reactions, and Temperature
- Acceleration, Forces, and Material Properties
- Electrochemistry and Batteries
- Solar Powered Cars
- Game Making in Scratch
- DNA and Genetics

High School Lab Activities

- Extraction and Quantification of Curcumin from Turmeric
- Determination of Copper Content in Pennies

SUSTAINABILITY

In designing the outreach program, we aimed to ensure sustainability for the program to maximize the long-term impact of the activities. The program has benefitted from significant community contributions, including free bus fare for students to and from the outreach events and discounted lunches from local restaurants. Additionally, the program is now supported by the Camille and Henry Dreyfus Foundation, which has facilitated generating new laboratory exercises and expanding the program infrastructure. Coupling with the above investments, one key design element of the program is the low cost of each of the individual labs. Key supplies for each lab, which may include minor pieces of equipment, glassware, etc., typically range from \$100 to \$300 per lab. By judiciously designing labs to keep additional costs to a minimum, running each outreach activity is comparatively inexpensive.

To ensure sustainability of student volunteers, we have involved mentors from different levels ranging from high school students to graduate students. To maintain this support pipeline, we anticipate that once in high school, many current middle school students in the program will return as near-peer mentors for younger students. To maintain a significant pool of graduate student volunteers, we have aimed to cultivate the program as a career-development opportunity for students interested in teaching careers. Because we now have many developed lab modules, students can easily get involved without

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the need to develop new curriculum. Alternatively, graduate students are encouraged to design new lab modules each year, which provides more hands-on curriculum development experiences than would otherwise be available in teaching assistant assignments for undergraduate-level teaching courses. Although born from a budgetary crisis, the high level of adaptability of the program allows for the scaffold to be applied to new contexts as the needs of the students and mentors evolve.

■ EVALUATION

To ensure the maximum impact, sustainability, and relevance of the program, we collect feedback from students and also critically evaluate the program on a regular basis. During the first two and a half years of the program, over 450 middle school students have participated over the course of 22 outreach events. Additionally, we have had 96 high school student visits, and 19 high school students have volunteered as near-peer mentors for the middle school activities. In addition to tracking student numbers, we solicit student feedback after each outreach module to generate internal review board-approved survey data. At the end of each lab, the students fill out the evaluation, answering questions both about the lab performed and their overall views of science. These surveys also contain questions pertaining to students' self-image as a scientist and their perceptions about science (Figure 2). The

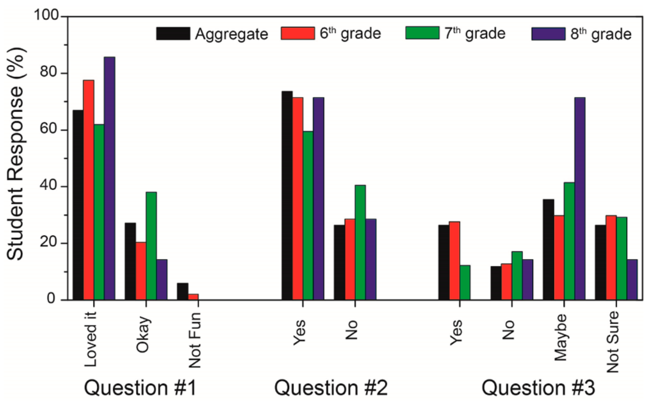

Figure 2. Middle school student feedback from outreach activities. Data is shown for the combined aggregate responses as well as 6th, 7th, and 8th grade student groups. Question 1: How much fun? (Love it, Okay, Not Fun). Question 2: Did you feel like a scientist? (Yes, No). Question 3: Would you like to be a scientist when you grow up? (Yes, No, Maybe, Not Sure). In some cases, aggregate values may exceed the sum of individual grade responses because students were asked, but not required, to indicate their grade.

written comments, including responses to questions about what students experienced during the activities and what they would like to learn in future activities, are valuable for both fine-tuning developed labs and determining what types of new labs will be developed. Based on current responses in the program, over 75% of the students reported "I felt like a scientist today" and over 90% of students provided a positive response ("loved it!" or "okay") when asked how much fun they had during the activities. Additionally, when asked if they would like to be a scientist when they grow up, the majority of students responded "yes" or "maybe". In total, the student responses on the questionnaires show that our implementation objectives are being met and provide feedback for prioritizing new laboratory activities to dovetail with student interest.

In addition to evaluation from the middle and high school participants, we also collected survey data from the graduate student volunteers to gauge their enthusiasm for the program and also better understand student views on the importance of science education (Figure 3). A strong majority of student

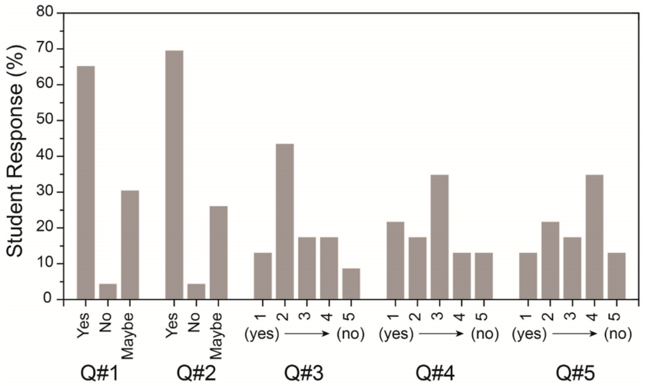

Figure 3. Graduate student feedback from outreach activities. Question 1: Do you plan to volunteer for "Furlough Friday" outreach events in the future? (Yes, No, Maybe). Question 2: Do you plan to list the "Furlough Friday" outreach program as an example of teaching/mentoring activities on you resume/CV? (Yes, No, Maybe). Question 3: Having predeveloped curriculum is important for encouraging new graduate students to get involved in outreach activities. Question 4: Participating in outreach is important to the professional growth of a Ph.D. student. Question 5: Do you think that the "Furlough Friday" program has changed the view of graduate students toward the importance of community science education? Questions 3–5 were ranked on a scale from 1 (yes) to 5 (no).

participants responded that they plan to (65%) or might (30%) volunteer for outreach activities in the future, suggesting that graduate students value participating. Additionally, almost all of the students surveyed responded that they plan to (70%) or might (26%) list their participation in the outreach program on their resume/CV as an example of teaching or mentoring experience. Graduate students also strongly agreed that having predeveloped labs was an important component of the program to encourage new students to get involved in outreach.

A major programmatic goal, beyond providing hands-on science education for middle and high school students, is to increase the awareness of graduate students to the importance of chemical education and connecting with the broader community. When polled, graduate students agreed favorably that participation in outreach events was an important professional development activity for graduate students. When asked whether the program had changed the view of graduate students in the department toward the importance of community science education, 35% responded that they agreed or strongly agreed. We believe this is a result of the fact that many graduate students in the program also participated in outreach as undergraduates and therefore already highly valued outreach, a view which was "unchanged" for the purpose of our survey. This feedback suggests that in addition to providing graduate students with out-of-classroom teaching and mentoring experience, the structured outreach activities have positively influenced the perceptions of the importance of science education to the broader community within the graduate student population.

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CONCLUSIONS

We have developed a multitiered outreach program that targets middle and high school students to supplement science education on days lost to budget cuts. The sustainable model also provides mentoring and leadership opportunities for high school, undergraduate, and graduate students. By incorporating near-peer student mentors across all the experience levels for the outreach activities, students benefit from a visible education pathway from middle school to college. The program also provides an example of a tightly integrated and collaborative model for sustainable science outreach that has both high educational impact and is structured to be a manageable time commitment for graduate students and research-active faculty. Taken together, the developed program, which is readily adaptable to different educational needs, has leveraged challenges associated with budget cuts in primary and secondary education to develop a scaffold for science outreach and mentoring that includes a diverse array of participants.

ASSOCIATED CONTENT

Supporting Information

Middle school student and graduate student surveys and data. This material is available via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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REFERENCES

(1) Long, G. L.; Bailey, C. A.; Bunn, B. B.; Slebodnick, C.; Johnson, M. R.; Derozier, S.; Dana, S. M.; Grady, J. R. Chemistry Outreach Project to High Schools Using a Mobile Chemistry Laboratory, ChemKits, and Teacher Workshops. *J. Chem. Educ.* **2012**, *89*, 1249–1258.

(2) Meyer, A. F.; Knutson, C. M.; Finkenstaedt-Quinn, S. A.; Gruba, S. M.; Meyer, B. M.; Thompson, J. W.; Maurer-Jones, M. A.; Halderman, S.; Tillman, A. S.; DeStefano, L.; Haynes, C. L. Activities for Middle School Students To Sleuth a Chemistry "Whodunit" and Investigate the Scientific Method. *J. Chem. Educ.* **2014**, *91*, 410–413.

(3) Kerby, H. W.; Cantor, J.; Weiland, M.; Babiarz, C.; Kerby, A. W. Fusion Science Theater Presents The Amazing Chemical Circus: A New Model of Outreach That Uses Theater To Engage Children in Learning. *J. Chem. Educ.* **2010**, *87*, 1024–1030.

(4) Lee, N. E.; Schreiber, K. G. The Chemistry Outreach Program: Women Undergraduates Presenting Chemistry to Middle School Students. *J. Chem. Educ.* **1999**, *76*, 917.

(5) Flynn, N. Science Days: An Interdisciplinary Outreach Program. *J. Chem. Educ.* **2005**, *82*, 1483.

(6) Van Doren, J. M.; Nestor, L. P.; Knighton, W. B. Engaging Students in the Action of Chemistry: An Effective, Fun, and Inexpensive Outreach Program. *J. Chem. Educ.* **1997**, *74*, 1178.

(7) Kesidou, S.; Koppal, M. Supporting Goals-Based Learning with STEM Outreach. *J. STEM. Educ.* **2004**, *5*, 5–16.

(8) Leshner, A. I. Outreach Training Needed. *Science* **2007**, *315*, 161.

(9) Alberts, B. M. Elementary Science Education in the United States: How Scientists Can Help. *Curr. Biol.*, *1*, 339–341.

(10) Rivoli, G. J.; Ralston, P. A. Elementary and Middle School Engineering Outreach: Building a STEM Pipeline; *Proceedings of the 2009 ASEE Southeast Section Conference*, April 5–9, 2009.

(11) Houck, J. D.; Machamer, N. K.; Erickson, K. A. Graduate Student Outreach: Model of a One-Day "Chemistry Camp" for Elementary School Students. *J. Chem. Educ.* **2014**, *ASAP Article,* DOI: 10.1021/ed400617r.

(12) Laursen, S.; Liston, C.; Thiry, H.; Graf, J. What Good Is a Scientist in the Classroom? Participant Outcomes and Program Design Features for a Short-Duration Science Outreach Intervention in K–12 Classrooms. *CBE-Life Sci. Educ.* **2007**, *6*, 49–64.

(13) Johnson, N.; Oliff, P.; Williams, E. An Update on State Budget Cuts. Center for Budget and Policy Priorities http://www.cbpp.org/cms/?fa=view&id=1214 (accessed Apr 2014).

(14) Williams, E.; Leachman, M.; Johnson, N. State Budget Cuts in the New Fiscal Year Are Unnecessarily Harmful. Center on Budget and Policy Priorities http://www.cbpp.org/cms/?fa=view&id=3550 (accessed Apr 2014).

(15) Hess, F. M.; Downs, W. K-12 Budget Picture: Lean Years Ahead. American Enterprise Institute for Public Policy Research http://www.aei.org/article/education/k-12/k-12-budget-picture-lean-years-ahead/ (accessed Apr 2014).

(16) DeWitt, J.; Osborne, J.; Archer, L.; Dillon, J.; Willis, B.; Wong, B. Young Children's Aspirations in Science: The Unequivocal, the Uncertain and the Unthinkable. *Int. J. Sci. Educ.* **2013**, *35*, 1037–1063.

(17) Osborne, J.; Simon, S.; Collins, S. Attitudes towards Science: A Review of the Literature and its Implications. *Int. J. Sci. Educ.* **2003**, *25*, 1049–1079.

(18) Wang, L. D. Furlough Friday Science Days. *Chem. Eng. News.* **2013**, *91*, 44.

(19) Program website: http://sciencefriday.uoregon.edu/ (accessed Apr 2014).

(20) Wilson, Z. S.; Holmes, L.; Degravelles, K.; Sylvain, M. R.; Batiste, L.; Johnson, M.; McGuire, S. Y.; Pang, S. S.; Warner, I. M. Hierarchical Mentoring: A Transformative Strategy for Improving Diversity and Retention in Undergraduate STEM Disciplines. *J. Sci. Educ. Technol.* **2012**, *21*, 148–156.

(21) Markus, H.; Nurius, P. Possible selves. *Am. Psychol.* **1986**, *41*, 954–969.

(22) Tenenbaum, L.; Anderson, M.; Jett, M.; Yourick, D. An Innovative Near-Peer Mentoring Model for Undergraduate and Secondary Students: STEM Focus. *Innov. High. Educ.* **2014**, 1–11.

(23) Jett, M.; Anderson, M.; Yourick, D. Use of Near-Peer Mentoring to Involve Minority Jr/High School Students in Science. *FASEB J.* **2006**, *20*, A541–A541.

(24) Laursen, S. L.; Thiry, H.; Liston, C. S. The Impact of a University-Based School Science Outreach Program on Graduate Student Participants' Career Paths and Professional Socialization. *J. High. Educ. Outreach Engagem.* **2012**, *16*, 47.

(25) Voegel, P. D.; Quashnock, K. A.; Heil, K. M. The Student-to-Student Chemistry Initiative: Training High School Students To Perform Chemistry Demonstration Programs for Elementary School Students. *J. Chem. Educ.* **2004**, *81*, 681–684.

(26) Anderson, A. M.; Mitchell, M. S.; Mohan, R. S. Isolation of Curcumin from Turmeric. *J. Chem. Educ.* **2000**, *77*, 359–360.

(27) MacCormac, A.; O'Brien, E.; O'Kennedy, R. Classroom Activity Connections: Lessons from Fluorescence. *J. Chem. Educ.* **2010**, *87*, 685–686.

DOI: 10.1021/ed500377m
J. Chem. Educ. 2015, 92, 625–630

(28) Quach, H. T.; Steeper, R. L.; Griffin, G. W. An Improved Method for the Extraction and Thin-Layer Chromatography of Chlorophyll A and B from Spinach. *J. Chem. Educ.* **2004**, *81*, 385−387.
(29) Tangney, B.; Oldham, E.; Conneely, C.; Barrett, S.; Lawlor, J. Pedagogy and Processes for a Computer Programming Outreach Workshop-The Bridge to College Model. *IEEE Trans. Educ.* **2010**, *53*, 53−60.
(30) Cady, S. G. Music Generated by a Zn/Cu Electrochemical Cell, a Lemon Cell, and a Solar Cell: A Demonstration for General Chemistry. *J. Chem. Educ.* **2014**, *91* (10), 1675−1678.
(31) Council, N. R. *Learning Science in Informal Environments: People, Places, and Pursuits*; The National Academies Press: Washington, DC, 2009.
(32) What kinds of learning happen in ISE experiences: http://informalscience.org/research/wiki/What-kinds-of-learning-happen-in-ISE-experiences (accessed Sept 2014).
(33) *Taking Science to School: Learning and Teaching Science in Grades K-8*; The National Academies Press: Washington, DC, 2007.

DOI: 10.1021/ed500377m
J. Chem. Educ. 2015, 92, 625−630