A New Approach of Science, Technology, Engineering, and Mathematics Outreach in Climate Change, Energy, and Environmental Decision Making

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Abstract

Preparing a literate public to critically evaluate issues related to climate change, energy, and the environment is an important pillar toward more sustainable societies. In this article, we focus on how informal education and outreach programs that have a combined focus on science, technology, engineering, and mathematics (STEM) and on climate change can improve knowledge, produce interest in STEM careers, and prepare educators to communicate and teach issues at the crossroads of STEM and climate change. The first part of this article describes the structure of STEM outreach programs for K-12 students and teachers in various parts of the United States. The second part presents, in detail, the structure and results of the outreach program SUCCEED (the Summer Center for Climate, Energy, and Environmental Decision-Making), a K-12 outreach program created by Carnegie Mellon University's Department of Engineering and Public Policy (EPP). SUCCEED aims to 1.) improve scientific literacy through a summer program focusing on climate, energy, and environmental decision making for students entering 10th grade and K-12 teachers; 2.) encourage the pursuit of STEM-related careers, and 3.) help teachers prepare curriculum in these disciplines, to be used in their classes. This article also discusses how both the university and the local community can benefit from outreach programs like SUCCEED.

Introduction

To combat the effects of climate change, society will need to adapt and employ more sustainable, low-carbon, energy systems. This will require a labor force prepared to understand, assess, and deploy large-scale, low-carbon technological solutions. Research shows that providing universal primary and secondary education helps train a workforce able to, for instance, improve economic growth and reduce population vulnerability to natural disasters.[1-3]

More broadly, preparing a strong science, technology, engineering, and mathematics (STEM) workforce has long been central to the ability of the United States to successfully compete with other countries, the ability to manufacture better and smarter products and services, to improve health care, to develop cleaner and more efficient domestic energy sources, to preserve the environment, and to safeguard national security.[4] Indeed, the National Science and Technology Council argues that to continue growing the U.S. economy, the country will need to maintain its leadership in STEM fields.[4] The employment market responds to such needs: STEM

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employment is predicted to grow about 13 percent between 2012 and 2022.[5]

Despite high demand, only 16 percent of American high school seniors are proficient in mathematics and interested in a STEM career.[6] Compared to the other countries that are part of the Organization for Economic Co-operation and Development (OECD), U.S. students rank 26 out of 34 in math and 21 out of 34 in science.[7] This lack of proficiency extends through to college and resulting careers. Of the subset of U.S. students who attend college and complete a bachelor's degree, only 16 percent major in STEM fields[8] and only half of these (8 percent of the bachelor's degree recipients) choose to work in a STEM career. Women and minorities, who correspond respectively to 50 percent and 43

Table 1. Select U.S. University STEM Outreach Programs for K-12 Students

Program	Organizer	Target	General Structure	Duration	Cost
4-H Career Explorations Conference [9]	Cornell University	Students entering grades 8- 9; Focus for Teens program for youth entering grades 10-12	Students get exposed to academic fields and career exploration to develop leadership skills, provide hands-on experience in a college setting and introduce them to Cornell University.	3 days in the summer	Small fee
Breakfast of Science Champions[10]	Ohio State University; Ohio STEM Outreach	Middle school students	Students spend a morning on campus and enjoy breakfast with faculty and graduate students from sciences, mathematics, and engineering to learn about career opportunities and attending college. Students then tour labs and participate in a variety of activities.	Half day	
Minority Engineering Program - Camp Engineer[11]	Ohio State University; Ohio STEM Outreach	Middle school students	Students work on design projects as well as participate in engineering departmental tours and workshops that help introduce them to specific engineering disciplines.	1 week	
Northeastern University Summer STEM Program (NUSSP)[12]	Northeastern University; Center for STEM Education	Students entering grades 6, 7, and 8 who are historically underserved, and underrepresented students with limited opportunities	Students attend classes that include problem solving, research, critical thinking and communication skills incorporated with biology, chemistry, physics, environmental sciences, earth sciences, engineering, technology, design concepts, and field excursions. Activities include experiments, projects, and field trips.	2 weeks	Free
RISE[13]	Stanford University; Stanford Office of Science Outreach	Low income students (16 yrs. old)	Students spend 30 hours a week working in a research lab under the guidance of a mentor from the lab (typically a graduate student), and attending weekly group sessions that include field trips, presentations, hands-on science activities, and lab tours.	7 weeks in the summer	Students receive a stipend of $2,500.
STEM Summer Institute[14]	MIT; MIT Office of Engineering Outreach Programs	Local students in 5th, 6th, 7th, or 8th grade	The program includes lectures and hands-on activities in math, science, and engineering with MIT undergrad students.	5 weeks in the summer	Free
Summer Science Research Program (SSRP)[15]	Rockefeller University	High school students (16 years and older)	Biomedical lab experience including doing research, reading the relevant literature, and participating in lab meetings.	7 weeks in the summer	Free. Stipends are available when needed.

MARY ANN LIEBERT, INC. • Vol. 8 No. 5 • October 2015 • DOI: 10.1089/sus.2015.29023.ff

percent of school-age children, are disproportionally underrepresented in STEM fields (25 percent and 15 percent, respectively).[16, 17] This raises the question of whether outreach and informal educational activities could help illustrate the relevance of STEM to high school students. Such programs are especially valuable if they can also impact student attitudes[18] and provide an opportunity for scientists to teach and share information, thereby increasing public trust.[19]

This article is focused on how informal education and outreach programs with a combined focus on STEM and climate change can increase knowledge, generate interest in STEM careers, and prepare educators to communicate issues at the crossroads of STEM and climate change.

Recent findings suggest important knowledge gaps remain in what concerns climate change, energy, and environmental literacy. For example, a multiple-choice survey that received responses from 1,043 eighth-grade students in urban schools in two cities in Pennsylvania, showed that students had poor understanding of issues related to energy resources.[20] The survey results underscore the challenge of introducing interrelated environmental problems and the necessity of ensuring that teachers are well prepared so that they can provide students with the best possible education on topics relating to energy resources and associated societal issues.[20] Similarly, when surveying the public on their understanding of the energy used in day-to-day activities, it was found that people had a reasonable idea of how much energy is used by small appliances, but their perception of energy use by larger appliances was substantially underestimated.[21-23] This suggests that improving climate science literacy will help address systemic holes, cognitive gaps, and misconceptions, which in turn could help the public better understand the scientific assessment of climate change and the significant risks it presents to individuals, businesses, and government (e.g., due to sea level rise and extreme weather).[24, 25]

One strategy that has emerged in recent years to help promote and sustain U.S. student interest in STEM fields is university-led K-12 outreach programs. This article reviews the characteristics and effectiveness of existing outreach STEM programs and from the Summer Center for Climate, Energy, and Environmental Decision Making (hereafter denoted as SUCCEED). The selection of existing programs included was based on a Google query of the following search words: *outreach, STEM, university,* and *United States*.

Examples and Characteristics of Existing Outreach STEM Programs

A variety of outreach programs in U.S. universities aim to improve and encourage STEM education for K-12 students and teachers. We collected the information about these programs exclusively from their websites.

K-12 Student Programs

Table 1 summarizes the characteristics of selected K-12 student outreach programs focused on STEM topics. Information about each program is often available on the university's website; it is unclear what other advertising mechanisms are used, and we have relied solely on the information available online in this article. Programs target students and schools local to the hosting university campus; some programs concentrate efforts on low-income students, minorities, or women. Most of the programs share similar objectives: to educate and engage students in STEM skills, introduce students to the university environment, and increase interest in STEM careers. Programs usually take place during school vacation periods, when students have time for immersive experiences, and can range in length from hours to weeks.

Short-term programs (less than four days), such as the Breakfast of Science Champions at Ohio State University and the 4-H Career Explorations, are more focused on introducing students to university life and raising interest in STEM topics and careers. Longer programs provide more in-depth experiences, such as the seven-week programs Raising Interest in Science and Engineering (RISE) hosted at Stanford University and the Summer Science Research Program (SSRP) at Rockefeller University (New York City). Both programs merge individual intensive laboratory work under the mentoring of faculty or graduate students with weekly group activities. Although duration of the programs varies substantially, teaching strategies are similar and usually incorporate lectures, hands-on activities, field trips, and interaction among professionals and students. Some sample activities include college level courses, such as robotics and calculus, taught by undergraduate students in the STEM Summer

Institute at MIT; and the field trip to the Marine Science Center in Nahant, Massachusetts, made in 2014 by students in the Summer STEM Program for middle school students (NUSSP) at Northeastern University.[12] While most programs are free, some have a cost attached or provide a stipend.

K-12 Teacher Programs

Table 2 presents selected K-12 teacher development programs in the area of science, technology, engineering, and math. The objective of these programs is to provide additional knowledge and teaching strategies in STEM topics for K-12 educators, especially by training teachers to apply more experiential, hands-on activities and real-world problem solving in the classroom. The Teaching & Learning with STEM Projects program hosted at Worcester Polytechnic Institute and CAPSULE at Northeastern University, for example, aim to develop theoretical and practical methods for STEM instruction using project-based teaching. Project-based teaching introduces designed challenges that require participants to apply scientific and mathematical concepts for solving interdisciplinary real problems.[26, 27] Other programs are part of the National Science Foundation (NSF) funding program Research Experiences for Teachers (RET). RET programs target multiple-week laboratory research that can be incorporated into the school curriculum while building long-term collaborative partnerships between K-12 STEM teachers and the NSF university research community.[28] University of Southern California Viterbi School of Engineering and Northeastern University have RET programs and were selected as examples because of the availability of detailed information about these initiatives. Additionally, there are programs that are designed to help teachers enhance their lesson plans through the development of lab experiments using everyday materials as a way to engage students in STEM topics. Examples include the Atoms & Molecules Workshops and DNA Workshops hosted at Edgerton Center at MIT, and the ASM Teachers Camp at the University of Illinois at Urbana-Champaign. Most of the programs happen during the summer and participation is free.

SUCCEED: The Summer Center for Climate, Energy, and Environmental Decision Making

SUCCEED is a K-12 outreach program created by Carnegie Mellon University's (CMU) Department of Engineering and Public Policy (EPP). The program was originally proposed and created under the auspices of the Climate and Energy Decision Making Center (CEDM), a multi-institution collaborative agreement anchored at CMU and supported by NSF. In subsequent years, SUCCEED was also supported by the CMU Leonard Gelfand Center for Service Learning and Outreach, The Grable Foundation, and the Westinghouse Electric Company Charitable Giving Program. Since its founding, SUCCEED has incorporated best practices from other CMU programs, such as the Green Design Apprenticeship[29] and the Summer Engineering Experience for Girls.

The program objectives are to: 1.) improve scientific literacy by providing a free summer program focusing on climate, energy, and environmental decision making for both students entering 10th grade and K-12 teachers; 2.) encourage pursuit of STEM-related careers; and 3.) help teachers prepare curriculum to be used in class. SUCCEED consists of two programs: a five-day workshop with approximately 20 students entering 10th grade, and a two-day workshop with approximately 10 math and science educators. SUCCEED has been held every summer since 2011.

General Characteristics

Carnegie Mellon University is exceptionally well positioned to support a STEM program on energy, the environment, and climate change. SUCCEED is organized by EPP doctoral students under the supervision of the department faculty. The co-directors draw on many university entities, including the Center for Climate and Energy Decision Making (http://cedmcenter.org), the Carnegie Mellon Electricity Industry Center http://wpweb2.teppes.cmu.edu/electricity., and the Scott Institute for Energy Innovation www.cmu.edu/energy and the Southwestern Pennsylvania Program for Deliberate Democracy (http://caae.phil.cmu.edu/caae/dpl), and university efforts to improve climate curricula,[30] to create an extensive network of academics, labs exercises, and industry contacts. In addition, several groups provide in-kind time support. To date, the groups that have provided some form of in-kind support include the Carnegie Museum of Natural History, First Energy (Bruce Mansfield and

Table 2. Select U.S. University STEM Outreach Programs for K-12 Teachers

Program	Organizer	Target	General Structure	Duration	Cost
Teaching & Learning with STEM Projects[26]	Worcester Polytechnic Institute; The STEM Education Center	STEM coordinators	Participants can choose between different workshops: Engineering Design/Bio medical Engineering, Earth's Place in the Universe, Matter and Its Interactions and Biological Evolution: Unity and Diversity	3-hour workshops during the academic year	$40 per meeting or $125 for the entire series
Atoms & Molecules Workshops and DNA Workshops [31]	MIT; Edgerton Center	K-12 teachers	Teachers participate in workshops and learn hands-on methods to improve their lectures	-	-
USC Viterby[28]	University of Southern California, Viterbi School of Engineering	K-12 STEM teachers	Lab-based research experience focused on engineering science and technology and advanced lesson study. Teachers collaborate with doctoral student and faculty.	6 week summer program	-
Research Experiences for Teachers (RET)[32]	Northeastern University; Center for STEM Education	Middle and high school mathematics and science teachers; community college STEM faculty	Participants work in research laboratories affiliated with the College of Sciences and Engineering.	6 weeks in the summer	Not available
CAPSULE[27]	Northeastern University and the Museum of Science in collaboration with the Boston Public Schools	K-12 STEM teachers	Participants are immersed in a variety of engineering experiences supporting the development of a menu of engineering capstone experiences for the high school classroom.	2 weeks in the summer	• $1,500 stipend for participation in the two-week course • $250 for each follow-up meeting and participation in online community • up to $500 toward supporting classroom materials and supplies • Graduate credit is available.
ASM Teachers Camp[33]	University of Illinois at Urbana-Champaign; Department of Materials Science and Engineering	High school teachers (public, private, independent) in math, science, and technology	Participants experience simple labs and experiments using everyday materials that can be integrated into lesson plans to actively engage students in applied science.	Full day (8:00 a.m. to 5:00 p.m.), 5-day-long workshop in the summer	Free

Beaver Valley Power Plant), Aquion Energy, the CMU Intelligent Workplace, and the CMU Electric Vehicle Lab. SUCCEED supporters include undergraduates, graduates, staff, faculty, industry, and government.

Administratively, SUCCEED was run by volunteer EPP doctoral students (co-directors), with either Inês Azevedo (2011-2013), Kelly Klima (2013-2014) or Parth Vaishnay (2015) as a faculty/staff advisor. Co-directors spend between 160-250 hours a year on SUCCEED, and their activities include advertisement, applications review, program/schedule development, and human resources administration. Co-directors are present throughout all activities, though the SUCCEED team also includes an ethnically and gender diverse group of students and faculty, who each plan and conduct activities or lectures for the workshops. In 2012, 16 CMU students, staff, and faculty volunteered their time; in 2013 this number grew to 26 volunteers and in 2014, to 28 volunteers.

Five-Day Student Program

The five-day summer school program for students entering 10th grade consists of a variety of activities that include conventional classes, laboratory activities, field trips (e.g., thermal and nuclear power plants, a battery manufacturing facility), and other hands-on activities related to energy and climate change (see Appendixes A, B, and C for sample agenda; Appendixes are available online at www.liebertpub.com/sus). Energy topics discussed in the program include: how power plants work, nuclear energy, renewable energy (solar, wind, and hydro), fossil fuels, energy consumption, batteries, and life cycle assessment. Climate change topics include: climate science, mitigation and adaptation, and underscoring the relationship between energy generation and greenhouse gas production. Volunteers incorporate student-centered learning through fun, engaging activities and demonstrations such as a scavenger hunt (2012-2014), science olympics (2012), cooking with an outdoor solar cooker (2013-2014), and a hands-on role playing game involving simulated hydraulic fracturing (2014), among others. Each year, the program has concluded with participants mounting a final presentation or debate, which is open to parents and teachers as well as all members of the CMU community. The program is free of charge, and includes breakfast, lunch, and transportation.

Two-Day Teacher Program

The two-day workshop targeting K-12 science teachers consists of lectures, activities, and lesson planning with one day focused on climate, and one day focused on energy (see Appendix B for sample agenda). Program mornings are focused on lectures from experts followed by discussion. Afternoons are reserved for the creation of lesson plans related to topics discussed during the morning and exchange of ideas between the participant teachers and EPP community. Doctoral students also organize the program, but there is greater participation of CMU faculty than in the student program. Participant teachers receive Act 48 Credit (credits required to maintain a teaching certificate in the state of Pennsylvania) and a $200 stipend for their participation.

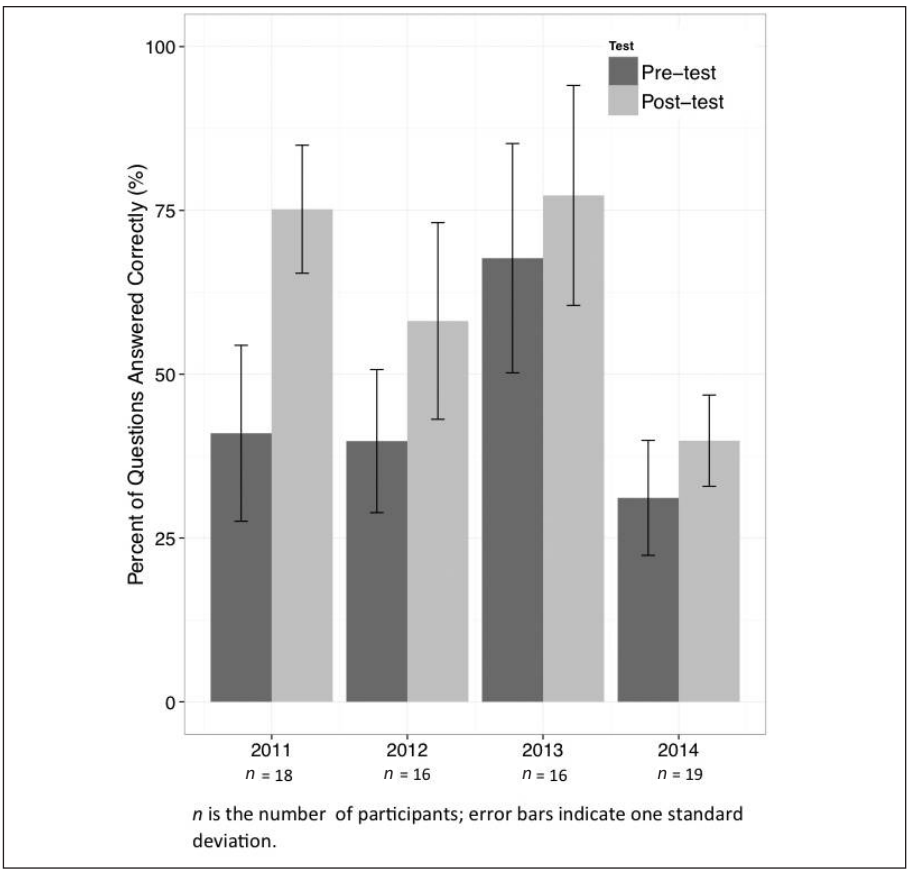

Figure 1. Percentage of questions answered correctly in the student pre- and post-tests for students participating in SUCCEED in years 2011 to 2014

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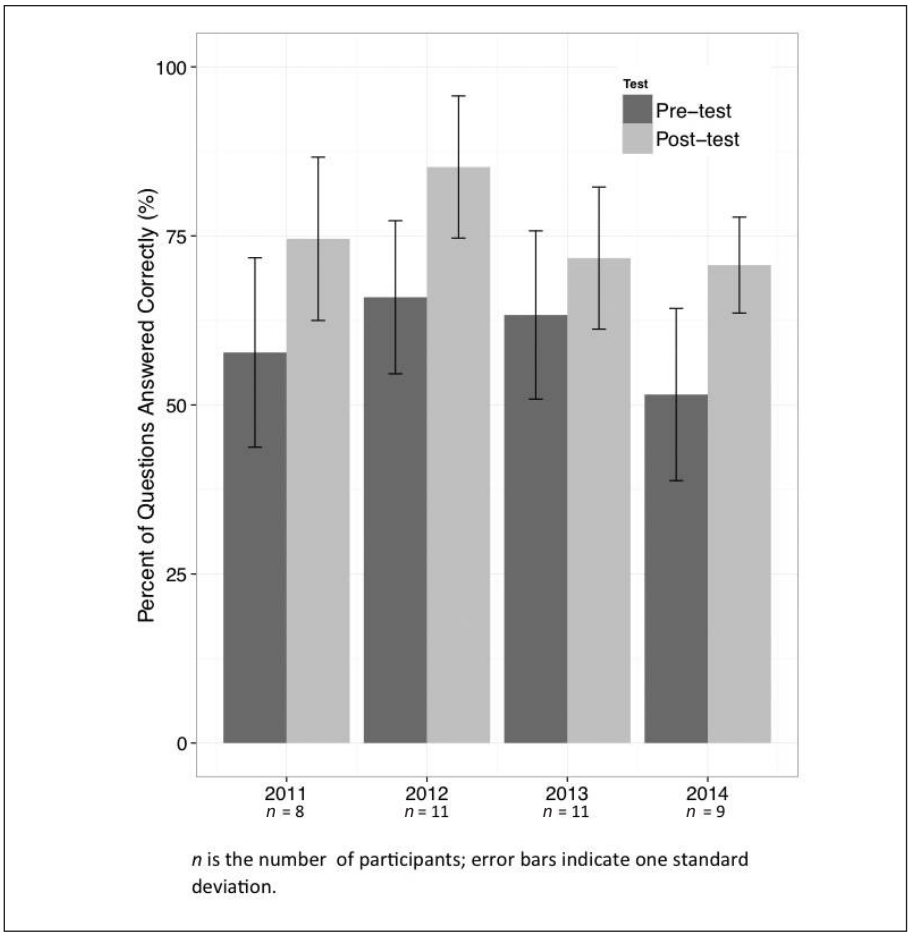

Figure 2. Teacher pre- and post-tests

SUCCEED Outcomes

To assess increased knowledge acquired in the SUCCEED program, participants were given a pre-test and a post-test. Approximately 75 percent of the questions remained the same throughout all three years; remaining questions varied as a function of particular subjects covered in a given year. The questions in the pre- and post-questionnaire from each year are provided in Appendix C. Results from these tests are shown in Figure 1 for the student workshop and Figure 2 for the teachers' workshop.

For each year's worth of data, we performed a paired *t* test on the difference between the pre-test and post-test results of each participant (separately for students and for teachers). Student performance improved significantly in all four years (p <0.01 each year from 2011-2014) when pre- and post-tests are compared. A similar pattern was observed in teacher performance over the four years ($p < 0.05$ for each year from 2011-2014). Lower significance levels in the improvements for teacher performance reflect the small sample size of teachers relative to students. Further analysis of these results and discussion of trends in the responses to specific questions will be presented in future work.

Unlike what was publicly available about other university programs, SUCCEED has documented its outcomes through Internal Review Board (IRB) approved pre- and post-tests (see Figure 1 and Figure 2) to assess knowledge acquisition. The tests were refined each year to focus more directly on misconceptions and gaps in knowledge, so inter-year comparisons are not entirely accurate. Questions that remained the same for all four years of the study are listed in Table 3 and Table 4.

Due to IRB privacy considerations, demographic data, other than tar-

Table 3. True/False Questions. All questions in this category were presented with three answer choices: "True," "False," and "Not Sure" (or in some years, "Don't Know")

1. Nuclear plants release carbon dioxide (CO_2) into the air.
2. We could completely avoid human-induced climate change if the whole world would concentrate on having more efficient and sustainable farming practices.
3. The carbon dioxide (CO_2) released from the combustion of fossil fuels can stay in the atmosphere for over 100 years.
4. Electricity generated from solar panels costs less than that from coal power plants.
5. An energy efficient light bulb—compact fluorescent lamps (CFLs), or light emitting diodes (LEDs— lasts the same amount of time as a conventional incandescent light bulb.

Table 4. Multiple Choice Questions. In some years, answer option "Don't know" was presented as "Not sure," and the answer option shown in questions 6.e. and 7.d. was not present in certain years.

6. These are examples of renewable energy sources:
   a. wind power.
   b. natural gas.
   c. nuclear power.
   d. solar power.
   e. burning wood to make electricity
   f. none of these answers.
   g. not sure.

7. We use batteries to power things like phones or laptops because
   a. batteries are a portable way of storing energy.
   b. batteries are a cheap way of storing energy.
   c. it is a corporate conspiracy between Energizer and Duracell.
   d. batteries are "green" and don't emit pollution over their lifecycle
   e. none of these answers.
   f. not sure.

8. The Marcellus Shale includes hard layers of rock under Pennsylvania. It contains fuel that can be used to make energy. The types of fuel that are being removed include:
   a. coal.
   b. radon.
   c. natural gas.
   d. none of the above.
   e. not sure.

get population, cannot be reported. Noting this caveat, each year shows an increase in knowledge among all participants. Furthermore, of their own accord, many students, teachers, and parents have approached the authors to provide additional participant testimonials regarding SUCCEED's impact.

In addition, SUCCEED has also collaborated with the Leonard Gelfand Center for Service Learning and Outreach to create a lesson plan database for the program topics, which is publicly available for teachers and educators.[34] Figure 3 shows a screenshot of one aspect of the curricula; approximately 20 lesson plans that meet common core math curriculum or next generation science standards are now available on the website.

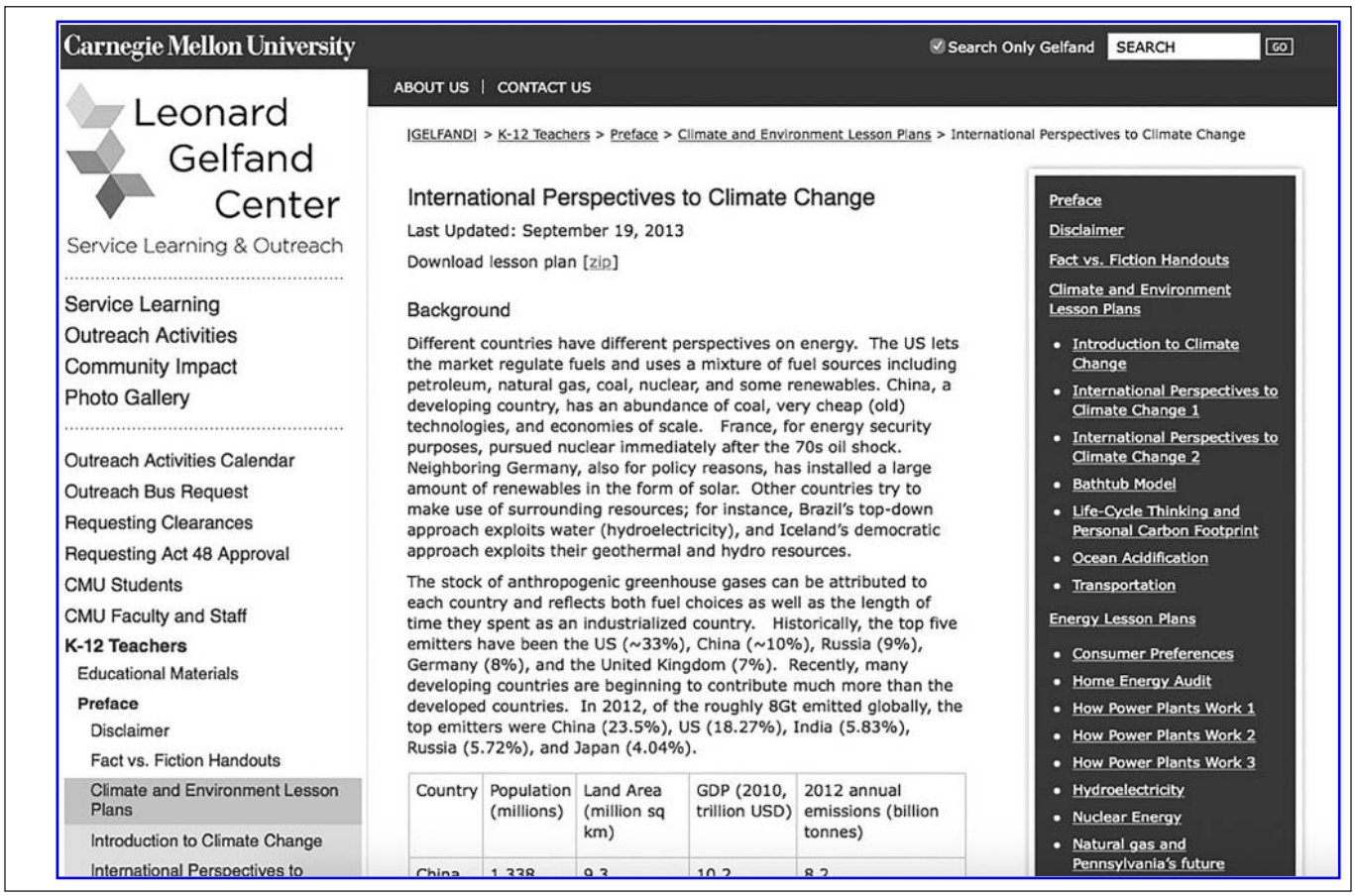

Figure 3. Screen shot of online curricula database at Carnegie Mellon University, which now includes "Climate and Environmental Lesson" plans

Discussion

SUCCEED's format, cost, and range of role models combine to form a unique package that directly contributed to the outcomes and long-term impacts identified by the authors.

First, the dual nature of the SUCCEED program (workshops for both students and for teachers) allows for a number of important synergies. Experience gained during the student workshop allows the directors to provide more refined guidance during the teacher workshop. Select lesson plans developed for use during the student workshop were also provided to participating teachers. Similarly, engagement with high school teachers provides insight into the structure and challenges of the current high school curriculum, which yields insights for future years. The dual workshops also have an important impact on recruitment, as teachers and students learn about the program from each other and can report on their experiences.

Second, many participants were especially motivated and excited by the extensive range of role models provided. For many participants, SUCCEED was their first experience with a university campus, as well as their first contact with STEM professionals such as engineers. In addition, special sessions were organized in 2013 and 2014 for female participants to interact with female STEM doctoral students. Throughout SUCCEED, participants were often surprised by the idea that real engineers, researchers, and scientists come from a variety of backgrounds and do not follow common stereotypes. Due to the number of volunteers, the volunteer-to-student age proximity, and the student-centered learning, the instructors were able to easily connect with student participants. Similarly, the teacher workshop lessons included active learning and direct interactions with faculty. In contrast, many other programs take place either in a more formal environment or in shorter sessions throughout the year and are therefore less conducive to creating the same relationships and enjoyable associations with STEM fields.

Third, SUCCEED has been successful for 10th grade students partially due to the cost (free) and for K-12 teachers due to the stipend and the Act 48 credit. Some socioeconomically disadvantaged participants said that they would not have been able to attend SUCCEED without the support of free breakfast, lunch, snacks, and bus tickets. Furthermore, there are many programs competing for K-12 teachers, but teachers who participated said they were especially drawn to SUCCEED because of the stipend and Act 48 credit.

STEM programs such as SUCCEED are critical to continued success in improving knowledge, producing interest in STEM careers, and preparing educators to communicate and teach issues at the crossroads of STEM and climate change. Whether at Carnegie Mellon University or another location, the hope is that similar programs can continue to share knowledge and incorporate best practices to improve STEM outreach.

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Author Disclosure Statement

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References

1. Lutz W, Cuaresma JC, and Sanderson W. The demography of educational attainment and economic growth. Science 2008;319:1047-1048.
2. Muttarak R, and Lutz W. Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change? Ecol Soc 2014;19:42.
3. Lutz W, Muttarak R, and Striessnig E. Universal education is key to enhanced climate adaptation. Science 2014;346:1061–1062.
4. National Science and Technology Council. *Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strate-*

gic Plan. Office of the President, Washington, DC, 2013, pp. 1-143. https://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf (last accessed 08/24/2015).
5. United State Bureau of Labor. *Occupational Outlook Quaterly*. United State Bureau of Labor, Washington, DC, 2014, pp. 1-48. http://www.bls.gov/ooq (last accessed 03/24/2015).
6. United States Department of Education. Science, Technology, Engineering and Math: Education for Global Leadership. http://www.ed.gov/stem (last accessed 03/24/2015).
7. Organization for Economic Co-operation and Development (OECD.) Strong Performers and Successful Reformers in Education. Lessons from PISA 2012 for the United States. OECD, Paris, 2013. http://www.oecd.org/pisa/keyfindings/PISA2012_US%20report_ebook%28eng%29.pdf (last accessed 08/24/2015).
8. Cataldi EF, Green C, Henke R, et al. *2008–09 Baccalaureate and Beyond Longitudinal Study (B&B:08/09): First Look*. National Center for Education Statistics, Washington, DC, 2011. http://nces.ed.gov/pubs2011/2011236.pdf (last accessed 08/24/2015).
9. Cornell University Cooperative Extension. 4-H Career Explorations. 2015. http://nys4h.cce.cornell.edu/events/Pages/CareerEx.aspx (last accessed 08/24/2015).
10. The Ohio State University. Breakfast of Science Champions, STEM Outreach. https://stemoutreach.osu.edu/stem-programs/breakfast-science-champions (last accessed 03/24/2015).
11. The Ohio State University, College of Engineering. Minority Engineering Program. 2015. https://mep.engineering.osu.edu/mep-mission (last accessed 08/24/2015).
12. Northeastern University, Center for STEM Education. Summer STEM Program for Middle School Students (NUSSP). http://www.stem.neu.edu/programs/nussp/ (last accessed 03/24/2015).
13. Office of Science Outreach, Stanford University. RISE Summer Internship Program. 2015. http://oso.stanford.edu/programs/39-rise-summer-internship-program (last accessed 08/24/2015).
14. Massachussets Institute of Technology, Office of Engineering Outreach Programs. STEM Summer Institute. http://oeop.mit.edu/programs/stem/summer-institute (last accessed 08/24/2015).
15. The Rockefeller University. Summer Science Research Program. 2015. http://www.rockefeller.edu/outreach/highschoolapp (last accessed 08/24/2015).
16. National Academies of Sciences. *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. National Academies Press, Washington, DC, 2011. http://www.nap.edu/openbook.php?record_id=12984 (last accessed 08/24/2015).
17. Beede D, Julian T, Langdon D, et al. *Women in STEM: A Gender Gap to Innovation*. U.S. Department of Commerce, Economics and Statistics Administration, Washington, DC, 2011. ESA Issue Brief 04-11. http://www.esa.doc.gov/sites/default/files/womeninstemagaptoinnovation8311.pdf (last accessed 08/24/2015).
18. DeWaters JE, and Powers SE. Energy literacy of secondary students in New York State (USA). A measure of knowledge, affect, and behavior. Energy Policy 2011;39:1699-1710.
19. Fiske ST, and Dupree C. Gaining trust as well as respect in communicating to motivated audiences about science topics. Proc Natl Acad Sci USA 2014;111:13593-13597.
20. Bodzin A. Investigating urban eighth-grade students' knowledge of energy resources. Int J Sci Educ 2012;34:1255-1275.
21. Attari SZ, DeKay ML, Davidson CI, et al. Public perceptions of energy consumption and savings. Proc Natl Acad Sci USA 2010;107(37):16054-16059. http://www.pnas.org/content/107/37/16054.full (last accessed 08/24/2015). doi:10.1073/pnas.1001509107/
22. Attari SZ, DeKay ML, Davidson, CI, et al. Changing household behaviors to curb climate change: How hard can it be? Sus J Record 2011;4(1):9-11.
23. McCaffrey MS, and Buhr SM. Clarifying climate confusion: Addressing systemic holes, cognitive gaps, and misconceptions through climate literacy. Phys Geogr 2009;29:512-528.
24. United States Government Accountability Office (GAO). *High-Risk Series: An Update*. GAO, Washington, DC, 2013. http://www.gao.gov/products/GAO-13-283 (last accessed 08/24/2015).
25. Canfield C, Klima K, and Dawson JT. Using deliberate democracy to identify energy policy priorities in the United States. Energ Res and Soc Sci 2015; 8:184-89.
26. Worcester Polytechnic Institute. STEM Education Center PDs. http://www.wpi.edu/academics/stem/stempd-description.htm (last accessed 08/24/2015).

27. Northeastern University. CAPSULE @ Northeastern University. http://capsulenu.weebly.com/ (last accessed 08/24/2015).
28. University of Southern California. Viterbi School of Engineering. The RET Teacher Activities and Experiences. http://viterbi.usc.edu/k12/ret/ (last accessed 08/24/2015).
29. Matthews DH, Hawkins TR, Jaramillo P, et al. The green design apprenticeship. J Ind Ecol 2009;13:467-476.
30. Matthews D, and Klima K. FOCUS in climate: Flights of courses unified for students. Accepted at 2015 ASEE Annual Conference, 2015.
31. Edgerton Center. Massachussets Institute of Technology. Teacher Professional Development. 2015. http://edgerton.mit.edu/k-12/teacher-resources/teacher-pd (last accessed 08/24/2015).
32. Northeastern University. Center for STEM Education. Research Experiences for Teachers (RET). 2015.http://www.stem.neu.edu/programs/ret/(lastaccessed 08/24/2015).
33. University of Illinois at Urbana-Champaign. Department of Material Sciences and Engineering. ASM Teachers Camp. http://www.matse.illinois.edu/teacherscamp.html (last accessed 08/24/2015).
34. Carnegie Mellon University. Leonard Gelfand Center. Climate and Environment Lesson Plans. http://www.cmu.edu/gelfand/k12-teachers/succeed/climate-environment-lesson-plans/ (last accessed 08/24/2015).

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