122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #12738

Race, Inclusion, and Science: Things That Really Do Go Together

Dr. Jennifer R Amos, University of Illinois, Urbana-Champaign

Dr Amos joined the Bioengineering Department at the University of Illinois in 2009 and is currently a Sr Lecturer and Director of Undergraduate programs. She received her B.S. in Chemical Engineering at Texas Tech and Ph.D. in Chemical Engineering from University of South Carolina. She has developed and offered more than 5 courses since joining the faculty and has taken the lead roll in curriculum development for the department.

Dr. Carla D Hunter, University of Illinois, Urbana-Champaign

My program of research seeks to identify and analyze individual differences in the endorsement of various attitudes that characterize ethnic minority individuals' experiences of resilience and risk in the U.S. racial context. Specifically, I hope to understand how cultural factors (e.g., worldviews, gender), identity, and the experience of race-related stress (e.g., perceived racial discrimination, racial microaggressions) may buffer or place ethnic minorities at risk for the development of poor mental health outcomes. This program of research has broad implications for defining cultural variables, creating measures that may be used in research, and developing a model of ethnic minorities' well-being in a radicalized context.

Dr. Kathryn B. H. Clancy, University of Illinois, Urbana-Champaign

Dr. Kathryn Clancy is an Assistant Professor of Anthropology at the University of Illinois. Her research interests are in human reproductive ecology, particularly ovarian and endometrial function, as well as in issues of intersectionality and inclusion in science. Dr. Clancy and her collaborators have examined relationships between inflammation and ovarian function in rural agricultural and urban sedentary environments, and explored ways of non-invasively studying the endometrium in rural contexts. Recently she and her colleagues have empirically demonstrated the continued problem of sexual harassment and assault in the field sciences, and forthcoming results suggest a link between these experiences and the career trajectories of female scientists. She continues to perform research on issues of inclusion, identity, and diversity in science through collaborations with GAMES, the Committee for the Status of Women in Astronomy, and other organizations.

Dr. Ayesha Sherita Tillman, University of Illinois at Urbana-Champaign

Ayesha Tillman is an Illinois -STEM Education Initiative postdoctoral research associate currently working on several evaluations funded by the National Science Foundation and the National Institutes of Health. Ayesha Tillman received her Bachelor of Science in Psychology from Arizona State University and her Master of Arts in Research Psychology from California State University, Long Beach. She received her doctoral degree in Educational Psychology in the College of Education with a specialization in Evaluation. Prior to coming to Illinois, Ayesha worked as an education research associate in the Research and Evaluation Section of the Arizona Department of Education. Her research interests include the capacity of untrained versus trained evaluators, interdisciplinary STEM education evaluation, the evaluation of large multi-site educational programs, and using evaluation to positively impact higher education training programs. Her dissertation topic was: Using a values-engaged, educative evaluation approach to attend to diversity and equity in a multi-site science, technology, engineering, and mathematics program evaluation.

Race, Inclusion, and Science: Things That Really Do Go Together

Increasing diversity has emerged as an important goal for improving the productivity, innovation, and culture of science[1, 2]. Many current strategies play a numbers game: they try to increase the number of underrepresented students, both women and minorities, exposed to science, or increase the number recruited[3]. Yet, exposure and recruitment do not solve broader issues of inclusion, nor do they address structural inequalities and biases that inhibit retention. There is a growing body of literature that highlights the crucial role that engagement with science plays in helping underrepresented students "see" themselves as scientists. We aimed to extend the work in this area and suggest that thinking about broader historical and social contexts of engineering, as well as the role of engineering to improve society, may be especially relevant for girls' engagement with engineering. The social sciences contain many tools to encourage students to develop problem-solving skillsets that help them understand the positive force context dependence and awareness of biases can play in the scientific enterprise. Social science methodologies contradict the notion of engineering as purely objective, which can be less alienating for individuals with identities that have been traditionally marginalized.

Over the last two years we have introduced social science methodologies and concepts to high school students through the Girls Adventures in Math Science and Engineering (GAMES) camp as a way to test the hypothesis that social science may be used to facilitate and improve girls' engagement with STEM fields. First, we will outline the context of GAMES. Next, we will present the principles and methodologies that guided our approach to the girls' engagement at camp. Finally, we will provide two examples of the types of didactic and experiential exercises that were used. We have found GAMES participants were excited to engage and ask scientific questions around the social construction of their identities (e.g., gender, race) and bodies (e.g., body image, stress). The motivation and engagement of these emerging scholars demonstrated the importance of our model.

GAMES Camp

Girls' Adventures in Mathematics, Engineering, and Science (GAMES) is an annual week long camp, designed to give academically talented high school girls (rising 9th-12th graders) an opportunity to explore engineering and scientific fields through demonstrations, classroom presentations, hands-on activities, and contact with women in these technical fields. The camp has been offered at the University of Illinois at Urbana-Champaign since 2007 and now offers 9 different tracks across the engineering sub-disciplines. The Bioengineering camp structure changed from a more traditional overview of the field with labs into a more focused camp in 2012 which includes morning lectures and short activities led by social scientists that engage the girls in discussions of a social and psychological nature and set the framework for the day. In the afternoon, the campers perform scientific and engineering experiments and design projects related to the morning topic. The intended long-term impact is to enrich the educational experience through technical education that uses a more inclusive, holistic view of social science integration that piques interest in STEM disciplines among underrepresented students, and provides a framework for current issues such as healthcare, health disparities, and sustainability.

GAMES Camp Schedule, July 14th-July 20th, 2014							
Theme	Opening						Closing
	Sunday	Monday, 7/14	Tuesday, 7/15	Wednesday, 7/16	Thursday, 7/17	Friday, 7/18	Saturday
7:00 AM		Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
7:30 AM							
8:00 AM							
8:30 AM		Walking time	Walking time	Walking time	Walking time	Walking time	
8:45 AM		Social Science Lecture and Activity	Social Science Lecture and Activity	Social Science Lecture and Activity	Social Science Lecture and Activity	Social Science Lecture and Activity	
9:00 AM							
9:30 AM		Break	Break	Break	Break	Break	Check Out
10:00 AM		Project Details	BIOPAC Playtime	Project Time	Stem Cell Mechanics Lecture and Lab	Biometrics	
10:30 AM							
11:00 AM			Walking time				Closing Ceremony
11:30 AM		Walking time	Admissions Lunch	Walking time	Walking time	Walking time	
11:45 AM		Lunch		Lunch	Lunch	Lunch	
12:00 PM							
12:30 PM							
12:45 PM		Walking time	Walking time	Walking time	Walking time	Walking time	
1:00 PM		Frog Dissection: Muscle and Nerve Lab	Biomimetics Lecture and Lab	Mini-Ethnography study on Quad & Experiment Time	Bone Dissection and Mechanics Testing	Work on Presentation	
1:30 PM							
2:00 PM						Project Presentations	
2:30 PM							
3:00 PM		3D Printing Lecture and BioBots Lab	Biomechanics motion capture modeling	AFM of Hair Lecture and Lab	Review Data/ Work on Presentation		
3:30 PM							
4:00 PM						Wrap Up	
4:30 PM							
5:00 PM		Walking time	Walking time	Walking time	Walking time	Walking time	
5:30 PM	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	
6:00 PM							
6:15 PM	Phsyio of MS System & Experiment with wood skeleton						
6:30 PM							
6:45 PM		Camp Olympics	EBICS BioBots Ethics Module	College Night		Talent Show	
7:00 PM							
7:30 PM							
8:00 PM	Floor Meeting						
8:30 PM							
8:45 PM				Talent Show Practice			

Figure 1: Schedule for GAMES Bioengineering 2014

Guiding Principles

Principle 1: Science in the service of society. Many of the existing science, technology, engineering and mathematics (STEM) engagement opportunities operate on a "deficit model" form of science outreach. That is, they are unidirectional and share new knowledge with the public, under the assumption that the public would become more engaged with science if they just knew more of it[4].The GAMES model brings girls together for a week, consistently engaging them on the relationship to what they are doing in their lab exercises to the real world. The Bioengineering track of the camp has moved from a unidisciplinary context to a transdisciplinary context to show the campers the broad, social implications of engineering[5]. Underlying this desire to connect science, engineering and society was our hope that young prospective engineers could be recruited to be a generation that prioritizes an inclusive environment. We see this approach as adaptable to the K-12 classroom for more diverse groups, including mixed-gender classrooms.

Principle 2: The importance of engaging with science. Research on STEM engagement suggests that sustained interactive models are more successful at engaging the public, creating more lifelong learners, bringing underrepresented minorities and women into science, and retaining them as future scientists and engineers[6]. Current research suggests that girls are more likely to pursue STEM careers if they see its connection to society[7, 8] and we would contend that this is the case for many groups underrepresented in science. Giving the girls an interdisciplinary perspective connecting social science thinking in the morning to the laboratory work they performed in the afternoons would, we hoped, help them see that their contribution to bioengineering could be much more than quantities pipetted or petri dishes observed under a microscope.

Principle 3: Awareness of the social and historical context of science. Awareness of the social and historical context of science and society motivates internal change as well as an external commitment to social justice. There are multiple ways to facilitate emerging engineers to thinking about diversity, categories, social science, and social justice. We chose to do so with race because of the overwhelming evidence that race is socially constructed[9, 10, 11], yet the continued belief by many in popular culture and some scientific disciplines that it is largely biological.

GAMES Lesson Plans: An Integration of Science

In this paper, we present two examples of social and engineering education integration at GAMES. These examples were carried out in the 2013 (n=29) and 2014 (n=32) offerings of the summer camp

The social context and science of hair. In our first year of the camp, we devised a lesson on race and hair to help students think about the ways their ancestry and cultural conditioning influenced their hair texture and hairstyle choices. We knew the girls would be using an AFM microscope as part of the hands-on learning at the camp, thus combining a conversation about race and ancestry with the ability to observe differences in hair under the microscope would help students connect social issues with laboratory methods. As the GAMES girls tend to be about two thirds white, we also thought introducing small group and intergroup interaction would be an important way to engage on this topic[12].

We began the lesson, led by Dr. Kathryn Clancy, with a discussion question: What do you think creates hair variation? We kept track of the factors mentioned by the students on the blackboard, then used a few of these factors to ask students to group themselves. Students chose hair color and texture. When the students with the darkest hair came together, all but one were students of color, and one South Asian student exclaimed with a grin, “Hey, it’s the brown girls group!” Aside from that comment, when we asked students to notice how these hair groupings might be relevant to other categories, students were unwilling to volunteer observations about race or ancestry. We gave them time in their small groups, and again in a second round of grouping when they organized themselves around other hair variables, to discuss their hair and the similarities and differences within and between groups.

At this point, Dr. Clancy gave a presentation defining genetics and environment as a way to explore race and ancestry. She discussed the many genes that produce variation in hair color and texture, and the many products and treatments that also produce variation in hair color and texture. She provided images of hair under a microscope, and encouraged the students to consider their own hair color, texture, and style. The students were asked to compare some hair microscope images and consider what genetic or environmental factors might have made them different. One white student insisted that culture and society played no role in the hair choices she made, that she chose her hairstyle out of her own preferences. The instructor pointed out that the student's hair was long and blow-dried straight – did these decisions not in some way conform to current expectations for girls? The student insisted no. Other students shifted uncomfortably in their seats, and the instructors tried to open it up for a broader conversation, which led only to a surface-level, stilted conversation.

In the lab, Dr Jennifer Amos delivered a brief overview of Atomic Force Microscopy. The girls were then asked to describe differences in hair that they learned or observed in the morning discussion. Some characteristics that the girls suggested were texture of hair, hypothesizing that African American hair would be rougher than Caucasian hair and that African American hair would be oilier than Caucasian hair. These hypotheses were based on discussions about the differences in hair-care products for the two ethnic groups. We then went to the lab to test these hypotheses. Two girls from each ethnic group donated a piece of hair to put on a microscope slide for the AFM. We scanned all of the hairs looking at sub-micron scale texture differences in the hair (Figure 2). The girls then made observations and drew conclusions on their hypotheses.

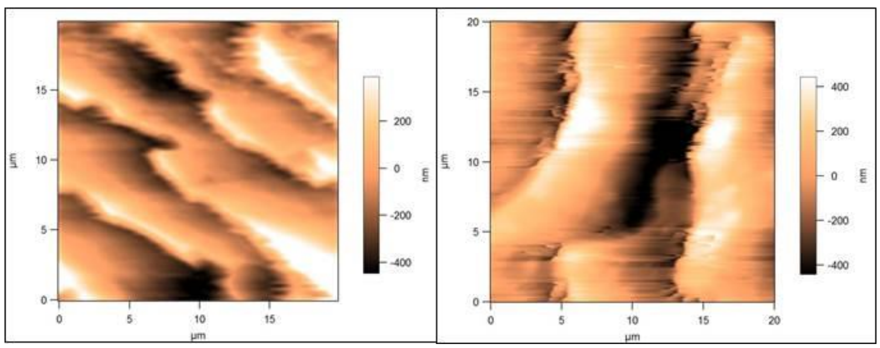

Figure 2: 20um AFM scans of hair mounted on glass microscope slides.
Left: Caucasian hair sample, Right: African American hair sample

Observations drawn from the images were that the African American hair was smoother and Caucasian hair seemed more damaged and rough. The girls were then asked to get into teams and pretend that they are engineers trying to design for artificial hair to mimic certain hair qualities that they desired. Without the pre-discussion of ethnic differences, the girls might not understand the differences in hair that they saw in the experiment or form deeper questions about hair-care products and how they can alter their hair.

From the hair discussion and experiment, we concluded that students were unprepared to discuss race in a way that was personal, and informal conversations with these students suggested many were afraid of accidentally being racist. This is consistent with literature on introducing concepts of race as a social construction to college-level classes[13]. Therefore, we sought to find a different way to engage students on issues of race that broadened the conversation to issues of environment, socioeconomic context, and marginalization/privilege for the second year of the experiment.

Using science to achieve health equity. Ethnic minorities are more likely than White individuals to receive poor health care[14, 15]. These disparities in key areas of health, while alarming, reflect the realities of ethnic minorities' social environments (i.e., racism, discrimination, and race-related stress), and are not simply the consequence of individual behaviors and choices[16]. Bronfenbrenner's Ecological Systems Theory has many benefits that facilitate building emerging engineers' knowledge and awareness of how systems impact development, including the racial health disparities in the U.S.

Dr Carla Hunter used Bronfenbrenner's Ecological Systems Theory to illustrate the various contexts that play a role in development. For the didactic portion of the lesson, the Ecological Systems Theory was introduced and explained. According to the theory, individuals' contexts are comprised of 4 systems that are interrelated, often with the individual at the center. The microsystem is typically the individual's immediate environment and consists of home, school, and work. The next system, the mesosystem refers to interactions between microsystems (e.g., between school and one's church). The third system, the exosystem are those settings where the person may not be present, but nonetheless have an impact on individuals' lives (e.g., parents' employment conditions). The last system is the macrosystem and involves the cultural norms, values, and ideologies of society (e.g., equality, liberty, freedom of speech).

Ecological systems, however, have limited utility without the inclusion of the opportunity for experiential learning. To start, students were invited to consider the meaning of the word environment and who and what is included in their own environments. Such an initial question encouraged students to consider the microsystems that comprise their environments. Many students mentioned their schools, their neighborhoods, and community organizations. Students were then encouraged to think about the entire ecology and to complete their personal ecological systems maps. After giving the students ten minutes to complete the exercise they were asked to report to the larger classroom what they learned. The students smiled as they realized the similarities in their perceptions of the microsystem. However, considering contexts at the levels of the exosystem and macrosystem posed more challenging. During the large group discussion students were offered that school boards and accreditation bodies are important parts of their exosystem. The social scientist leading this portion of the lesson then reflected on personal experiences of the perception of equality in the U.S. as an ideology at the level of the macrosystem that influences how we think about our own and others' academic success.

Given students enhanced understanding of ecological systems we then introduced racial health disparities because we felt it mapped nicely with GAMES camp focus and facilitated the girls' understanding of engineering as a mechanism for addressing these health disparities. The girls were asked to identify the reasons for health disparities and to subsequently work in small groups to create their visions for health equity and what would need to happen at each level of the ecological system to facilitate health equity (e.g., reduce the number of Black mothers' preterm births). The girls embraced this idea and generated feasible suggestions that included an understanding of protective factors at the level of the microsystem, for example family support during times of stress, access to quality maternal health care in one's neighborhood. At the mesosystem level interventions focused on parenting classes at the local community center or developing mommy and me discussion groups while at the exosystem level childcare during doctor's appointments for mothers who already have children may facilitate consistent attendance for prenatal checkups. Finally the at the macrosystem level affordable insurance and shifting the burden of childcare from mothers to all caregivers, including fathers and grandparents, which may lessen mothers' feelings of isolation and childcare burden.

In the afternoon, the campers were led through an activity by a group of University of Illinois engineers who designed biological robots, bio-bots, using a hydrogel, heart cells, and a 3D printer (Figure 3)[17]. Campers are walked through a series of ethics scenarios relating to the engineered bio-bot including terrorists take over the bio-bots, bio-bots reproduce, and bio-bots learn and evolve. Dr. Ayesha Sherita Tillman helps the girls form groups and address these scenarios as well as answer follow up questions relating to the ethics and social impact of engineering. The campers seemed very open to discussing many of the ethical and social contexts of engineering advances for the public after the morning's discussion.

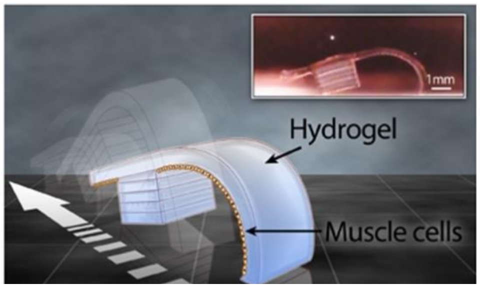

Figure 3. Artist rendering of BioBot[17]

Data from surveys administered for the camp were analyzed for interest in engineering as a career and confidence in engineering career choice. Data from experimental years, 2013 and 2014, were compared with the previous offering without social science integration in 2012 (n=30). Survey results were compared across all campers and no significant changes were seen based on demographic or grade level attributes. Campers were asked to "describe your level of interest in engineering" according to a Likert Scale (5 – very interested in engineering, 4 – interested in engineering, 3 – unsure of my interest in engineering, 2 – not very interested in engineering, 1 – not at all interested in engineering) and "how sure you are that you would be an engineer if you wanted to be?" according to a Likert Scale (5 – Sure that I could be an engineer if I wanted to be, 4 – Pretty sure that I could be an engineer if I wanted to be, 3 – Unsure if I could be an engineer if I wanted to be, 2 – Pretty sure that I couldn't be an engineer if I wanted to be, 1 – Sure that I couldn't be an engineer if I wanted to be). These data combined with open ended responses show that there is a significant change in the campers' level of confidence in their ability to pursue a career in engineering in the two years of integrated social sciences versus without. A student t-test shows response to survey questions with control group prior to the social integration (n=30) compared independently to two experimental years yields a mean of 4.2 ± 1.1 $p \leq 0.06$ for 2013 (n=29) and mean 4.2 ± 1.1 $p \leq 0.08$ for 2014 (n=32) for confidence in career in engineering in post-camp surveys. Preliminary data on the camps' impact on student interest in engineering demonstrated a small, but not yet significant, increase in interest after camp compared to camp surveys without social integration. When comparing the Bioengineering track to other GAMES tracks, BIOE campers reported an 8% increase in interest in engineering and confidence in engineering careers. Students also provided open-ended responses to the survey and comments were positive about the experience (Figure 4).

"I was really surprised how the environment has influence over us"

"I really liked how [we] talked about some 'taboo' topics for our age like race and gender roles"

"Small groups really helped with difficult conversations"

"It was neat to see how our mind, body, and social network are all connected and how they interact"

Figure 4. Quotes from post-camp surveys

Evaluators qualified to conduct evaluations and instruments that yield valid assessments of important outcomes of STEM programs are rare[18]. In particular, the need for evaluations that attend meaningfully and respectfully to issues of culture, race, diversity, and equity is not currently met[19]. Therefore, interdisciplinary evaluation teams have become increasingly necessary to plan, implement, evaluate, and disseminate results of STEM educational programs. The evaluation of the GAMES program utilized the values-engaged, educative (VEE) approach[20]. The VEE approach, developed with NSF-HER support, defines high quality STEM educational programming as that which effectively incorporates cutting-edge scientific content, strong pedagogy, and sensitivity to diversity and equity issues.

As engineers are facing grand challenges and work more and more in interdisciplinary teams, we think that integrated social science and engineering will provide the needed mindset for breakthrough solutions. A 2013 report on the role of "21st century skills" identified the related skills as clusters of competencies in cognitive, intrapersonal, and interpersonal domains that included aspects like creativity, flexibility, collaboration, and conflict resolution[18]. Engineers propose that "a true, complete solution to many of the problems we care about should include economics, psychology, behavior, sociology[21]". K-12 education and outreach by universities provides an ideal platform to begin to develop engineering skills and engineering interest for the next generation. This type of integrated education also meets the 2013 Next Generation Science standards[22] including the emphasis on students' ability to "design solution in a safe and ethical manner, including considerations of environmental, social, and personal impacts"[23, 24]. In the coming year, we have the opportunity to offer this curriculum to a mixed gender audience as part of the Worldwide Youth in Science and Engineering camp called Discover Engineering, which is offered for rising sophomores. This camp will offer us a chance to test our curriculum on mixed gender and other diverse populations to increase our reach and gather more data for analysis. We will be keeping the curriculum the same and separating responses for female and male participants. Due to smaller camp numbers (20 total for both genders), this will need to be offered several times in order to reach a comparable sample size.

1. Cox, T. H., & Blake, S. (1991). Managing cultural diversity: Implications for organizational competitiveness. The Executive, 45-56.
2. Valian, V. (2004). Beyond gender schemas: Improving the advancement of women in academia. NWSA Journal, 16(1), 207-220.
3. Ceci, S. J., & Williams, W. M. (2011). Understanding current causes of women's underrepresentation in science. Proceedings of the National Academy of Sciences, 108(8), 3157-3162.
4. Hodson D (2003). Time for action: Science education for an alternative future. International Journal of Science Education, 25(6), 645-670.
5. National Research Council. Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond. Washington, DC: The National Academies Press, 2014.

6. Sadler T (2004). Informal reasoning regarding socioscientific issues: A critical review of research. Journal of Research in Science Teaching, 41(5), 513-536.
7. Metcalf, H (2010). Stuck in the Pipeline: A Critical Review of STEM Workforce Literature. InterActions: UCLA Journal of Education and Information Studies, 6(2), article 4.
8. Arnot, M., Gray, J., James, M., Rudduck, J., & Duveen, G. (1998). Recent research on gender and educational performance. London: OFSTED.
9. Gravlee, C. C. (2009). How race becomes biology: The embodiment of social inequality. American Journal of Physical Anthropology, 139, 47-57.
10. Williams, M., & Eberhardt, J. L. (2008). Biological conceptions of race and the motivation to cross racial boundaries. Journal of Personality and Social Psychology, 94, 1033-1315.
11. Delgado, R., & Strefancic, J. (2012). Critical race theory: An introduction. New York University Press.
12. Nagda, B. R. A., & Zúñiga, X. (2003). Forstering meaningful racial engagement through intergroup dialogues. Group Processes and Intergroup Relations, 6, 111-128.
13. Khanna C. & Harris, C. A (2009). Teaching race as a social construction: two interactive class exercises. Teaching Sociology, 37, 369-378.
14. Schiller, J. S., Lucas, J. W., Ward, B. W., Peregoy, J. A. (2012). Summary health statistics for U.S. adults: National Health Interview Survey, 2010 (Report No. 10). National Center for Health Statistics. Washington, DC: Government Printing Office.
15. U.S. Department of Health and Human Services, Healthy People 2020. (2014). Healthy people 2020 leading health indicators: Maternal, infant, and child health. Retrieved from https://www.healthypeople.gov/sites/default/files/HP2020_LHI_Mat_Inf_Child_0.pdf
16. Massey, D. S. (2008). Categorically unequal: The American stratification system. Russell Sage Foundation.
17. “These bots were made for walking: Cells power biological machines”. (November 15, 2012). Retrieved from http://news.illinois.edu/news/12/1115bio-bots_RashidBashir.html
18. Katzenmeyer, C., & Lawrenz, F. (2006). National Science Foundation perspectives on the nature of STEM program evaluation. In D. Huffman & F. Lawrenz (Eds.) Issues and challenges facing stem education and evaluation. New Directions for Evaluation, 109, 35–51. San Francisco, CA: Jossey-Bass.
19. Mertens, D. M., & Hopson, R. K. (2006). Advancing evaluation of STEM efforts through attention to diversity and culture. In D. Huffman & F. Lawrenz (Eds.), Issues and challenges facing STEM education and evaluation. New Directions for Evaluation, 109, 35–51. San Francisco, CA: Jossey-Bass.
20. Greene, J. C., DeStefano, L., Burgon, H., & Hall, J. (2006). An educative, values-engaged approach to evaluating STEM educational programs. In D. Huffman & F. Lawrenz (Eds.), Issues and challenges facing stem education and evaluation. New Direction for Evaluation (Vol. 109, pp. 53–71). San Francisco, CA: Jossey-Bass.
21. National Research Council. Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century. Washington, DC: The National Academies Press, 2012.
22. Carl Simon, Workshop on Key Challenges in the Implementation of Convergence, September 16-17, 2013, Washington, DC
23. National Research Council. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press, 2013.
24. NRC (National Research Council). (2012). A framework for K–12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: The National Academies Press. http://www.nap. edu/catalog.php?record_id=131