2018 ASEE Annual Conference & Exposition, June 24–27, 2018, Salt Palace Convention Center, Salt Lake City, UT

Year Two of the BEST Program: High School Science Teachers in Bioengineering

Dr. Anthony E. Felder, University of Illinois, Chicago

Anthony E. Felder is a Clinical Assistant Professor in the Richard and Loan Hill Department of Bioengineering at the University of Illinois at Chicago. Anthony's current focus is on undergraduate engineering education and its restructuring to better meet the diverse needs of students and industries. Accordingly, Anthony teaches a wide array of Bioengineering courses, from Introduction to BioE to Senior Design, Bioinstrumentation, and Cell and Tissue Engineering. Anthony is also active in ophthalmology research - having co-formed and currently serving as a Technical Director for the ophthalmology-based medical device design lab (ORBITLab) at the UIC Innovation Center. Anthony holds a B.S. and Ph.D. in Bioengineering.

Dr. Miiri Kotche, University of Illinois, Chicago

Miiri Kotche is a Clinical Associate Professor of Bioengineering at the University of Illinois at Chicago, and currently serves as Director of the Medical Accelerator for Devices Laboratory (MAD Lab) at the UIC Innovation Center. Prior to joining the faculty at UIC, she worked in new product development for medical devices, telecommunications and consumer products. She co-teaches both bioengineering capstone design courses, including the longstanding core senior design sequence and the recently launched interdisciplinary medical product development course. She also serves as co-Director of the Freshman Engineering Success Program, and is actively involved in engineering outreach for global health. Miiri received her Ph.D. in Bioengineering and M.S. in Mechanical Engineering from the University of Illinois at Chicago and a B.S. in General Engineering from the University of Illinois at Urbana Champaign.

Dr. Jennifer D. Olson, University of Illinois at Chicago

Jennifer Olson is a clinical assistant professor in the College of Education at University of Illinois at Chicago. She coordinates the Secondary Education program and teaches curriculum, instruction, & assessment courses to undergraduate and graduate secondary education students. Jennifer's research focus on urban high school reform is informed by nine years of teaching in Chicago Public Schools, giving her an informed perspective of how policy moves from theory to practice. Dr. Olson's current research interests include urban teacher preparation, teacher professional development and student voice. Her most recent publication in Journal of Urban Learning, Teaching and Research Becoming A Culturally Responsive Teacher: The Impact Of Clinical Experiences In Urban Schools focuses on elementary and secondary teacher candidates' perspectives of how their clinical experiences influence their preparedness in becoming effective culturally responsive educators.

Janet Aderemi Omitoyin, University of Illinois at Chicago

Janet Omitoyin is a PHD student in the Department of Curriculum and Instructions, University of Illinois at Chicago (UIC). An astute scholar, Janet's quest for a solution to the problems of mathematics learning based on her experience as a student and later as a teacher is at the root of her enrollment for a PHD program at UIC with a view to be part of the solution to the systemic problems emanating from inadequacies in the training of mathematics teachers that is at the core of this problem. Since enrollment at UIC, Janet had dedicated her studies and research efforts on Mathematics Socialization and identity amongst pre-service elementary teachers, an effort at understanding the reasons for lack of interest in the subject with a view to proffer solution and engender/motivate interest amongst this group that will eventually reflect in their classroom practices. She is currently a Graduate Assistant with UIC Engage, a community focused project that provides help for less-privileged students from K-8 in mathematics, reading and writing. She continues to work as a substitute teacher occasionally to keep abreast with current practices within the school system. Her work as a Research Assistant for the BEST program has turned out to be one of her best experiences as a graduate student with the educational and professional benefits that come with it. The program serves a dual benefit – her contributions to it success and the privilege to work with experienced researchers and science teachers.

Year two of the BEST program: high school science teachers in bioengineering

Abstract:

The Next Generation Science Standards (NGSS) are a set of K-12 science and engineering standards that require science teachers to deliver research-based, up-to-date science content knowledge. While Illinois adopted NGSS in 2014, the school districts and teachers must ultimately develop new curriculum to meet these standards. However, the development of such curricula can prove challenging to educators without experience in scientific research and engineering design. To address this gap in knowledge and facilitate the adoption of NGSS in Chicago Public High Schools (CPS), the University of Illinois at Chicago (UIC) Colleges of Engineering and Education developed the innovative Bioengineering Experience for Science Teachers (BEST) program. This program pairs selected BEST applicants (Fellows) with several UIC Bioengineering faculty members and their laboratories. Here, Fellows spend six summer weeks immersed in the laboratory environment, participating in individualized research projects under UIC Bioengineering faculty mentorship. During these six weeks, Fellows develop their research skills, explore engineering design, and enhance their scientific pedagogy. Ultimately, Fellows use this experience to develop new NGSS-compliant science and engineering curricula for incorporation into their classroom the following academic year. To support the adoption of NGSS-compliant curricula, all Fellows' curricula are uploaded to a centralized website for free download and use. Efficacy of the BEST program was assessed by mixed-method analysis surveys administered pre- and post-program in addition to weekly surveys administered throughout the program. The current study reports on the second successful year of the program. Key differences from the seminal year of the program include emphasis on mentorship between BEST Fellows and UIC Bioengineering faculty and dedicated workshop time for Fellows to develop curricula. These changes were introduced to further enhance Fellows' experience in the program and to facilitate the development of curricula under the supervision of UIC Bioengineering and Education faculty.

Introduction:

Science, technology, engineering, and mathematics (STEM) is at the foundation of modern society. However, only 52% of adults in the United States claim to be "very interested" in science and technology [1], in agreement with the well documented shortage of STEM professionals [2]. Moreover, only 28% of adults in the United States are classified as civic scientifically literate [3]. While a multitude of initiatives and approaches have been developed to increase interest and literacy in STEM [4]-[6], science education as a whole must also be enhanced. In recognition of this, the Next Generation Science Standards (NGSS) were developed. The NGSS are a comprehensive set of K-12 standards, designed to modernize and homogenize the teaching of science and engineering in the United States. Each NGSS standard is considered to have three dimensions: 1) disciplinary core ideas, 2) scientific and engineering practices, and 3) cross-cutting concepts [7][8]. Prior to NGSS, these dimensions were often taught at a disconnect and by separate teachers, to the disadvantage of the student. Moreover, NGSS establishes performance expectations related to each standard as well as coherence between standards [8][9]. To date, NGSS has been adopted by 19 states and is used to structure the science education of more than 35% of United States students [10]. However, the development of compliant curricula integrating these three dimensions [11] is the duty of individual teachers and remains a substantial challenge. This challenge is exacerbated by lack of exposure to modern scientific and engineering practices, studies, and advances. In fact, according to a recent study, fewer than 60% of surveyed high school teachers had strong science content knowledge, with more than 10% having none at all [12].

Previously, programs were developed to enhance the instructor's knowledge regarding science and engineering [13], including the National Science Foundation's Research Experience for Teachers program [14]-[16]; however, historically these programs did not provide formal instruction regarding the development of new curriculum, and in the case of [16], instruction focused on contextual inquiry - an approach not entirely consistent with NGSS's cross-cutting platform to building knowledge through use [11]. To address this limitation and facilitate the development of NGSS-compliant curricula within Chicago Public Schools (CPS), the Colleges of Engineering and Education at the University of Illinois at Chicago (UIC) developed the novel Bioengineering Experience for Science Teachers (BEST) program [17]. The BEST program is a six week summer immersion during which CPS high school science teachers are paired with UIC Bioengineering faculty mentors and engage in individual research projects. As part of their research, BEST participants learn about modern advances in science and engineering, expand their own skill sets, and establish connections within academia. From this immersion, participants develop new, research-based science and engineering curricula in compliance with NGSS. To facilitate the development of these curricula, weekly workshops were included in the program. During these workshops, participants discussed their research, experiences, and pedagogy, as well as spent dedicated time towards developing their curriculum under the guidance of UIC Bioengineering and Education faculty. While this program is similar in nature to other Research Experience for Teachers programs, the focus on instructional pedagogy in addition to content knowledge sets the program apart. Here we report on the second year of the BEST program.

Methods:

<u>Program Structure:</u>

The BEST program is a six week experience where CPS high school teachers are immersed in UIC Bioengineering laboratories for the purpose of developing new, NGSS-compliant curricula. Once accepted, teachers (i.e., BEST Fellows) are paired with Bioengineering faculty members and are immersed in his/her laboratory Monday-Thursday for up to 35 hours per week. Fellows also spend up to 4 hours per week under the supervision of their Bioengineering faculty member. In the laboratory, each Fellow progresses through an individual research project, scoped collaboratively by both the Fellow and faculty mentor. The Friday of each week is dedicated to a full-day BEST program workshop, where Fellows share their experiences that week, discuss teaching methodology, learn about NGSS, and plan their own curricula. By the conclusion of the program, BEST Fellows developed new curriculum according to their laboratory experience. Each Fellow's curriculum is developed according to the standards established by NGSS and is structured as a self-contained unit that fits within the larger scope of his/her classes. Moreover, each curriculum is connected to the context for learning at each individual school, to best serve that student population.

Currently, the BEST program is a paid summer experience, with Fellows receiving $7,500 at the end of the program after the successful submission of their curriculum, and a further $500 after implementing their curriculum in the classroom. Direct scaling of the program is limited due to the issuing of stipends and the amount of participating Bioengineering faculty, however the posting of developed curricula online ensures that the efforts of Fellows to develop NGSS-compliant curricula can be utilized by teachers across the country.

<u>Fellows and Laboratory Placements:</u>

In 2017, more than 40 CPS high school teachers applied to the program and ultimately only eight were selected to participate. Fellows, their schools, and laboratory placements are provided in Table 1. Fellows were of mixed racial background, sex, and from schools that served varied demographics to holistically represent the CPS system. Schools were classified as either neighborhood (i.e., schools that caters to students within a defined neighborhood boundary) or selective enrollment (i.e., a school that caters to students outside of an immediate boundary, as determined by standardized testing scores). Each lab corresponded to a unique field in Bioengineering and placement of Fellows was determined based on preference and aptitude.

Table 1. Participants in the 2017 BEST program

BEST Fellow	Years Teaching	Race	Sex	High School	School Type and Demographics [18]	Lab/Project Focus and Bioengineering Faculty
KC	10	White	Male	John F Kennedy	Neighborhood school, 75% Low income;	Cell and tissue engineering of liver

				High School	Student population: 73% Hispanic, 21% White, 4% African American, 2% Other	constructs for drug screening, led by Salman Khetani, Ph.D.
RF	5	African American	Male	Gwendolyn Brooks College Preparatory Academy HS	Selective Enrollment school, 71% Low income; Student population: 80% African American, 18% Hispanic, 1% White, 1% Other	Using electroencephalography measurements to explore the brain connectome, led by Alex Leow, M.D., Ph.D.
HH	3	Asian	Male	Jones College Prep	Selective Enrollment school, 39% Low income; Student population: 14% African American, 29% Hispanic, 39% White, 13% Asian, 5% Other	Development and characterization of metal biomedical implant materials, led by Mathew Mathew, Ph.D.
VJ	17	Asian	Female	Lake View High School	Neighborhood school, 81% Low income; Student population: 9% African American, 71% Hispanic, 13% White, 4% Asian, 3% Other	Assessment of biomineralization in ferritin proteins, led by Tolou Shokuhfar, Ph.D.
CM	7	African American	Male	David G Farragut Career Academy High School	Neighborhood school, 99% Low income; Student population: 9% African American, 90% Hispanic, 1% Other	Design and 3D printing of lab equipment for low-resources environments, led by David Eddington, Ph.D.
SN	15	White	Female	Greater Lawndale High School for Social Justice	Neighborhood school, 98% Low income; Student population: 11% African American, 88% Hispanic, 1% Other	Assessment of airway and lung acoustics as an early markers of disease, led by Tom Royston, Ph.D.
ES	17	Asian	Female	Roald Amundsen High School	Neighborhood school, 83% Low income; Student population: 12% African American, 59% Hispanic, 13% White, 14% Asian, 2% Other	Development of phantoms for use in motion-sensitive magnetic resonance imaging, led by Dieter Klatt, Ph.D.

LS	6	White	Female	Albert G Lane Technical High School	Selective Enrollment school, 47% Low income; Student population: 8% African American, 41% Hispanic, 35% White, 11% Asian, 5% Other	Development and application of rehabilitation robotics, led by Jim Patton, Ph.D.

Program Deliverables and Surveys:

By the conclusion of the program, BEST Fellows developed new NGSS-compliant curriculum according to their lab experience. These curricula, including lesson plans, in-class activities, assignments, etc., are posted online through the BEST program website (https://bestbioe.uic.edu/) and may be freely adopted by other educators. BEST Fellows are then expected to implement their new curriculum in class during the coming academic year.

To assess the effect of the BEST program, Fellows were requested to participate in mixed-methods pre- and post-program surveys. These surveys contained quantitative and qualitative questions (Likert scale and open-ended short answer, respectively) to assess Fellows' understanding of pedagogy and bioengineering topics. Additionally, weekly surveys were administered to determine BEST Fellow progression throughout the program and to provide feedback about their experience that was either promoting or hindering their success in the program. Lastly, to determine when BEST Fellows implemented their new curricula, two additional surveys were administered at the end of Fall 2017 and Spring 2018 semesters. All surveys were mixed-method and contained both qualitative and quantitative questions. The administration and data collection of all surveys was approved by the Institutional Review Board at UIC.

Data Analyses:

Quantitative questions on surveys were answered using a 5-point Likert scale between strongly agree/positive (1) to strongly disagree/negative (5). Paired t-test was used to determine the effect of the program on paired pre- and post-program survey questions. General linear model repeated measures analysis was used to determine the effect of time on paired weekly survey questions. All statistical analyses were performed using SPSS statistical software (version 24, SPSS, Chicago, IL, USA). Statistical significance was accepted at $P < 0.05$.

Results:

Weekly Surveys:

Best Fellows' answers to questions from the weekly surveys are presented in Table 2. Data here correspond to a 5-point Likert scale from strongly agree/positive to strongly disagree/negative (1 and 5, respectively). The effect of time on answers is provided. Briefly, there was no effect of the time on Fellows' weekly experience in their lab (Q5_1) and the Friday curriculum workshop (Q5_2), with averages of 1.74 ± 1.17 and 1.88 ± 0.87, respectively. These scores indicate experiences between positive and strongly positive. There was a significant effect of time on agreement that Fellows' learning was adequately supported (Q3_4; P = 0.026) and that Fellows would be able to transfer their new knowledge to the classroom (Q3_5; P = 0.004). Lastly, there was no effect of time on agreement that collaboration with other Fellows was helpful, with an average of 1.48 ± 0.74. This score indicates responses between agree and strongly agree that Fellow collaborations were helpful.

Table 2. Questions and Fellows' answers from the weekly surveys (N = 7). Data correspond to a 5-point Likert scale from strongly agree/positive to strongly disagree/negative (scores of 1 and 5, respectively). Data are presented as mean ± standard deviation. Asterisk indicates statistical significance (P < 0.05).

Question	Week 1	Week 2	Week 3	Week 4	Week 5	P-value
(Q5_1) Please rate your overall experience - In your bioengineering lab	1.85 ± 1.21	2.29 ± 1.60	1.29 ± 0.49	1.57 ± 0.79	1.71 ± 1.49	0.521
(Q5_2) Please rate your overall experience - In the curriculum workshop	2.00 ± 0.57	1.86 ± 0.69	1.86 ± 0.69	1.86 ± 0.69	1.86 ± 1.57	0.996
(Q3_4) Please rate the extent to which you agree or disagree with the following statements regarding your lab experience . - My learning is adequately supported.	2.43 ± 1.62	2.71 ± 1.60	1.71 ± 0.76	1.71 ± 0.76	1.43 ± 0.53	0.026*
(Q3_5) Please rate the extent to which you agree or disagree with the following statements regarding your lab experience . - I will be able to transfer my	1.85 ± 0.90	2.86 ± 1.21	1.21 ± 0.49	1.43 ± 0.53	1.43 ± 0.53	0.004*

learning in the lab to my classroom						
(Q4_7) Please rate the extent to which you agree or disagree with the following statements regarding the curriculum workshop. - Collaboration with the BEST teachers is helpful	1.43 ± 0.53	1.57 ± 1.13	1.43 ± 0.79	1.43 ± 0.53	1.57 ± 0.79	0.987

Paired Pre- and Post-Program Survey Questions:

BEST Fellows' answers to paired questions from the pre- and post-program surveys related to pedagogy and STEM topics/techniques are presented in Tables 3 and 4, respectively. In Table 3, Fellows were requested to rate their confidence level implementing the listed planning and instructional concepts and techniques into their teaching practice. In Table 4, Fellows were requested to rate their confidence level implementing the listed STEM topics and techniques into their teaching practice Data from both Tables correspond to a 5-point Likert scale from strongly confident to not confident at all (1 and 5, respectively). The effect of the program on answers is provided. Notably, there was a significant effect of the program on responses for each of the presented pedagogy and STEM questions ($P \leq 0.038$). Specifically, the largest changes in confidence levels were observed in relation to using the NGSS (Q6_10; $P = 0.006$) and the engineering method (Q9_5; $P = 0.022$).

Table 3. Paired pre- and post-program survey questions related to pedagogy and Fellows' answers (N = 8). Data correspond to a 5-point Likert scale from strongly confident to not confident at all (scores of 1 and 5, respectively). Data are presented as mean ± standard deviation. Asterisk indicates statistical significance (P < 0.05).

Please rate your confidence level implementing the following planning and instructional concepts and techniques into your teaching practice:	**Pre-Program**	**Post-Program**	**P-value**
(Q6_1) Using backwards design in lesson planning	2.5 ± 1.2	1.4 ± 0.5	0.015*
(Q6_2) Using essential questions to	2.6 ± 1.1	1.5 ± 0.8	0.015*

promote critical thinking			
(Q6_3) Connecting curriculum to students' culture and interests	2.6 ± 1.1	1.6 ± 0.9	0.033*
(Q6_4) Appealing to students' intrinsic motivation	2.8 ± 0.9	1.5 ± 0.8	0.005*
(Q6_5) Creating rubrics for assessment	2.9 ± 1.0	1.5 ± 0.8	0.004*
(Q6_6) Using questioning techniques to check for students' understanding	2.5 ± 0.9	1.1 ± 0.4	0.008*
(Q6_7) Differentiating to meet all students' needs	2.9 ± 0.8	1.8 ± 0.7	0.007*
(Q6_8) Creating assessments aligned to learning objectives	2.8 ± 1.0	1.4 ± 0.7	0.008*
(Q6_9) Using assessments to inform instruction	2.8 ± 1.0	1.5 ± 0.8	0.011*
(Q6_10) Using Next Generation Science Standards to inform my planning and instruction	3.3 ± 1.3	1.6 ± 0.7	0.006*

Table 4. Paired pre- and post-program survey questions related to STEM topics/techniques and Fellows' answers (N = 8). Data correspond to a 5-point Likert scale from strongly confident to not confident at all (scores of 1 and 5, respectively). Data are presented as mean ± standard deviation. Asterisk indicates statistical significance (P < 0.05).

Please rate your confidence level implementing the following STEM topics and techniques into your teaching practice:	**Pre-Program**	**Post-Program**	**P-value**
(Q9_1) Applying the scientific method	1.9 ± 0.6	1.3 ± 0.5	0.011*
(Q9_2) Documenting test protocols and results appropriately	2.8 ± 1.4	1.4 ± 0.5	0.020*
(Q9_3) Employing statistical calculations for experiments	3.5 ± 1.2	2.3 ± 1.3	0.038*

(Q9_4) Employing lab safety techniques	2.0 ± 0.5	1.3 ± 0.5	0.003*
(Q9_5) Employing the Engineering Design Method	3.7 ± 1.0	1.8 ± 0.7	0.022*

Curriculum implementation:

The first round of the final survey was sent to BEST fellows in December 2017. From the responses, three Fellows had already implemented their curriculum in the Fall 2017 semester, following summer participation in the program.

Discussion:

In the second year of the Bioengineering Experience for Science Teachers program, we modified the Friday workshops to allow for more independent curriculum development time. This change provided more time for Fellows to develop their NGSS-compliant curricula with the assistance of both Engineering and Education program faculty. Moreover, we emphasized mentorship from the Bioengineering faculty to BEST Fellows, to provide a more enriched experience for both.

Weekly Surveys:

The weekly surveys allowed BEST Fellows to reflect on their progress through the program and their ability to develop new curricula according to NGSS. On average, BEST Fellows rated their time in their bioengineering labs between positive and strongly positive. From the weekly surveys, Fellows were asked to describe some of the lab activities that promoted their understanding of bioengineering. From their responses:

"*I think doing some background research, having conversations with the researchers, and asking questions helped me understand research and engineering better*",

"*I performed lab protocols, trouble shot, documented, and problem solved.*"

However, one Fellow had a negative experience due to logistics with his/her mentor, and when asked what experiences hindered his/her learning opportunities that week (i.e., the second week), replied:

"*[t]here has not been any official training or demonstration of laboratory protocols at this point.*"

However, as time progressed, BEST Fellows increasingly agreed that their learning was being adequately supported by their lab experience. For example, the same individual with the negative experience in the second week reported that there was nothing that hindered his/her learning in the sixth week.

BEST Fellows also rated their experience in the Friday workshop positively. Moreover, Fellows were in agreement that working together during these workshops was helpful. When asked what aspects of the workshop promoted their learning, Fellows responded: "*[s]haring out experiences and open group discussions*", "*[t]he readings and paired discussions regarding pedagogy was helpful.*" Further, as time progressed, Fellows grew more confident that they could transfer their new knowledge to the classroom. We attribute this trend to the dedicated curricula development time in the Friday workshops. When asked what was the highlight of their Friday workshops, Fellows responded:

"*having self directed time to work on my lesson planning*",

"*[h]aving a good chunk of time to work on the curriculum this week was the highlight. I felt this particular work session allowed for me to really focus on getting my curriculum jump started!*"

<u>Paired Pre- and Post-Program Survey Questions:</u>

To assess the effect of the program on generating NGSS-compliant curriculum, BEST Fellows were prompted with paired questions from the pre- and post-program surveys regarding pedagogy and STEM topics/techniques. The program significantly increased BEST Fellows' confidence implementing planning and instructional concepts and techniques into their teaching practice. Among these concepts and techniques were several relating to the students understanding of content. Interestingly, despite adoption of NGSS several years prior, Fellows responded to the pre-program survey with only moderate confidence in using NGSS to inform their planning and instruction. This result may, at least in part, be due to the lack of structured curriculum development at the individual classroom level. Moreover, many teachers lack adequate content knowledge in modern science and engineering advances, rendering generation of new curriculum difficult. However, after the program, BEST Fellows' confidence in using NGSS to inform their planning and instruction had significantly increased to between confident and highly confident.

The program also significantly increased BEST Fellows' confidence implementing STEM topics and techniques. Before the program, Fellows were of moderate or worse confidence regarding documenting test protocols and results, employing statistical calculations, and employing the engineering design method. After the program, confidence in each of these topics had significantly increased. In fact, the laboratory experience had increased confidence in documenting test protocols and results as well as employing the engineering design method to between confident and extremely confident. To additionally emphasize the engineering design method, a didactic lecture was given and a group discussion was curated. From the post-program survey, BEST Fellows were asked to provide an example of how they plan to employ the engineering design method in their class, to which one responded:

"*[t]he [engineering design method] is incorporated into the BEST curriculum through the development of a working component of a rehabilitation robot…students ARE required to design, prototype, test and program a working component of the rehabilitation robot they would employ in their research. As part of a final presentation, students will be expected to comment on how the [engineering design method] was utilized to develop their working component.*"

Another Fellow elected to incorporate engineering design in another way,

"*[s]tudents...will evaluate engineered solutions by comparing data sets about two different methods of cell culturing and determining which is optimal.*"

Future Plans:

We plan to make two modifications for the 2018 Bioengineering Experience for Science Teachers program year. First, we will provide more didactic content pertaining to NGSS, by specifically examining the structure of the requirements and tasks that are asked of students. Second, to further facilitate the mentor relationship, we will require that Fellows meet with their faculty mentor at least once a week, in the case that Fellows are coordinating with postdocs or other lab members.

It should be noted that due to the limited number of Fellows from the current program year (N=8), statistical power and ability to draw conclusions from survey data can be weakened. However, we plan to use these same survey questions in subsequent program years to substantiate these preliminary findings and elucidate the BEST program's efficacy. Furthermore, quantitative data analysis and results were presented and supported with individual qualitative responses from the survey questions. Future studies regarding this program may also perform comprehensive analysis on the qualitative data to better elucidate program efficacy. Lastly, we recognize that self-assessment, as presented here, is a relatively weak tool and we will integrate more stringent assessment methodology to determine the effects of the program. These tools include expert assessment and better written questions to accurately determine Fellow content knowledge.

Conclusion:

In conclusion, we report on the second year of the Bioengineering Experience for Science Teachers program at the University of Illinois at Chicago. This year, eight high school science teachers participated in the program and, according to their primary research projects, developed new curricula in compliance with NGSS. New this year was increased workshop time for curriculum development. Participants responded well to this and ultimately felt more confident in delivering their technical experience to students, using NGSS to inform their teaching, and employing the engineering design method. The ability for this program to successfully educate teachers in engineering can potentially be of high impact in a society with strong demand for technical careers. The curricula developed by participants is available online and is freely available for adoption.

Acknowledgements:

Research reported in this publication was supported by the National Institute of Biomedical Imaging and Bioengineering of the National Institutes of Health under award number R25EB021733-01. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References:

[1] J. D. Miller, "Civic Scientific Literacy in the United States in 2016," International Center for the Advancement of Scientific Literacy, Ann Arbor, MI, Rep., Oct. 2016.

[2] "STEM Integration in K-12 Education," National Academy of Engineering and National Research Council, National Academies Press, 2014.

[3] J. D. Miller, "The Sources and Impact of Civic Scientific Literacy," in *The culture of science: how the public relates to science across the globe*, New York: Routledge, 2012, pp. 217–240.

[4] S. Brophy, S. Klein, M. Portsmore, and C. Rogers, "Advancing Engineering Education in P-12 Classrooms," *Journal of Engineering Education*, vol. 97, no. 3, pp. 369–387, 2008.

[5] National Academy of Engineering and National Research Council, *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*. Washington: National Academies Press, 2009.

[6] R. Subramanian and S. Clark, "The partnership of University, Industry and K-12 Schools to improve awareness of STEM fields," presented at 2016 ASEE Mid-Atlantic Section Conference, Hempstead, NY, 2016.

[7] NGSS Lead States, “Executive Summary,” *Next Generation Science Standards: For States, By States*, 12-Jan-2018. [Online]. Available: https://www.nextgenscience.org/. [Accessed: Jan-2018].

[8] R. W. Bybee, “NGSS and the Next Generation of Science Teachers,” *Journal of Science Teacher Education*, vol. 25, no. 2, pp. 211–221, Aug. 2014.

[9] NGSS Lead States, “How to Read the Next Generation Science Standards (NGSS),” *Next Generation Science Standards*, Apr-2013. [Online]. Available: https://www.nextgenscience.org/. [Accessed: Jan-2018].

[10] National Science Teachers Association, “NGSS Adoption,” *About NSTA*. [Online]. Available: http://ngss.nsta.org/About.aspx. [Accessed: Jan-2018].

[11] J. Krajcik, S. Codere, C. Dahsah, R. Bayer, and K. Mun, “Planning Instruction to Meet the Intent of the Next Generation Science Standards,” *Journal of Science Teacher Education*, vol. 25, no. 2, pp. 157–175, Aug. 2014.

[12] J. Parker, T. J. McConnell, and J. Eberhardt. “Characterizing teachers’ incoming science content knowledge in a professional development program,” presented at the 2013 Annual International Conference of the National Association for Research in Science Teaching, Rio Grande, Puerto Rico, 2013.

[13] S. C. Silverstein, J. Dubner, J. Miller, S. Glied, and J. D. Loike, “Teachers Participation in Research Programs Improves Their Students Achievement in Science,” *Science*, vol. 326, no. 5951, pp. 440–442, 2009.

[14] A. E. Landis, C. D. Schunn, M. C. Rothermel, S. Shrake, and B. Niblick. “Development of a High School Engineering Research Program: Findings from a Research Experience for Teachers (RET) Site,” presented at 2011 ASEE Annual Conference & Exposition, Vancouver, BC, 2011.

[15] S. S. Klein-Gardner and A. C. Spolarich. “Impacts of the Vanderbilt University Research Experience for Teachers Program 2008 - 2010: Analysis of Student Surveys Regarding Motivational Impact,” presented at 2011 ASEE Annual Conference & Exposition, Vancouver, BC, 2011.

[16] G. Ragusa and M. J. Mataric. “Research Experiences For Teachers: Linking Research to Teacher Practice and Student Achievement in Engineering and Computer Science,” presented at the 2016 ASEE Annual Conference & Exposition, New Orleans, LA, 2016.

[17] S. Dreyer, M. Kotche, J. Olson, A. Shyjka. “Bioengineering Experience for High School Science Teachers,” presented at the 2017 ASEE Annual Conference & Exposition, Columbus, OH, 2017.

[18] “Chicago Public Schools,” *School Types and Demographics*. [Online]. Available: http://www.CPS.edu. [Accessed: Jan-2018].