Discovering the TeachEngineering Digital Library Classroom Impact

Dr. Marissa H. Forbes, University of Colorado Boulder

Marissa Forbes is a research associate in the College of Engineering and Applied Science at the University of Colorado Boulder and lead editor of the TeachEngineering digital library. She previously taught middle school science and engineering and wrote K-12 STEM curricula while an NSF GK-12 graduate engineering fellow at CU. With a master's degree in civil engineering she went on to teach advanced placement and algebra-based physics for the Denver School of Science and Technology, where she also created and taught a year-long, design-based engineering course for seniors. Forbes earned her PhD in civil engineering, with an engineering education research focus.

Dr. Jacquelyn F. Sullivan, University of Colorado Boulder

Jacquelyn Sullivan has led the multi-university TeachEngineering digital library project, now serving over 3.3M unique users (mostly teachers) annually, since its inception. She is founding co-director of the design-focused Engineering Plus degree program and CU Teach Engineering initiative in the University of Colorado Boulder's College of Engineering and Applied Science. With the intent of transforming engineering to broaden participation, Sullivan spearheaded design and launch of the Engineering GoldShirt Program at CU to provide a unique access pathway to engineering for high potential, next tier students not admitted through the standard admissions process; findings are very encouraging, and the program is being adapted at several other engineering colleges. Dr. Sullivan led the 2004 launch of ASEE's Pre-College Division, was conferred as an ASEE Fellow in 2011 and was awarded NAE's 2008 Gordon Prize for Innovation in Engineering and Technology Education.

Denise W. Carlson, University of Colorado Boulder

Carlson is involved with a broad range of program implementation initiatives through the Integrated Teaching and Learning Program at the University of Colorado Boulder's College of Engineering and Applied Science, including the TeachEngineering Digital Library. She holds a BA in economics from the University of Michigan Ann Arbor. She serves as a contributing author and editor of many publications, proposals, presentations and curricula.

Discovering the *TeachEngineering* Digital Library Classroom Impact: Executive Summary

TeachEngineering Digital Library

TeachEngineering (TeachEngineering.org) is a free, NSF-funded digital library of more than 1,500 hands-on K-12 engineering lessons and activities. A disseminator of original, standards-aligned engineering curricula created through more than 40 different NSF-funded engineering grants, the collection was accessed by over 3.2M unique users in 2016, realizing 19% annual growth. *TeachEngineering* also provides professional development opportunities to NSF-funded Research Experience for Teachers (RET) programs through interactive online seminars. The seminars introduce the K-12 RET teachers to the collection of engineering curricular resources and prepare them for the submission-to-publication process for their own classroom-tested engineering curricula.

Probing Project Impact

Seeking to ascertain the impact of the *TeachEngineering* digital library and outreach initiatives, in fall 2016 survey results from three teacher populations were sought via 10-minute quantitative and qualitative Qualtrics online surveys (see Table 1). The surveys probed self-reported differentials in 1) teachers' confidence in teaching engineering concepts and 2) changes in their teaching practices as a result of exposure to (and experiences with) K-12 engineering education resources and outreach opportunities, including the frequency with which they integrated engineering into their classroom teaching. The surveys employed a combination of Likert-style, open-ended, and multiple-choice questions.

Table 1: Descriptions of *TeachEngineering* (TE) impact surveys for three K-12 teacher populations.

Survey	Population
TE site pop-up survey	All TeachEngineering.org users from September 27 to November 4, 2016
TE published author survey	38 RET participant teachers whose curricula were published in the collection between January 1, 2014 and September 19, 2016
TE RET outreach survey	106 RET participants who attended a TE Google Hangout professional development seminar in summer 2016

TeachEngineering User Impact

During the 39 days that the pop-up survey ran, the *TeachEngineering* site had 373,840 unique users; 386 elected to take the survey (a self-selected and proportionally tiny sample size, which serves as a reminder that the results cannot be extrapolated to represent the full user population). The majority of respondents "strongly" (73%) or "somewhat" (16%) agreed that "after using the *TeachEngineering* digital library, [they] are more likely to integrate engineering concepts into [their] teaching."

Just over half (51%) of the respondents indicated that they were seasoned K-12 teachers (almost one-quarter of whom had been teaching for at least 20 years). More teachers were "highly confident" or "confident" in teaching engineering concepts to their students after using the *TeachEngineering* digital library curriculum (85%) as compared to before (35%) (chi-square $p<0.001$).

NSF RET Teacher Impact

Forty-four RET participants (42%) responded to the survey following their *TeachEngineering* Google Hangout seminars. Forty of the teachers (91%) had never heard of the TE collection before the seminar; 42 (95%) anticipated that they would use *TeachEngineering* curriculum in [their] classrooms in the future—a high pay-off for a 60-minute time investment by the *TeachEngineering* team.

Twenty-three RET teacher-authors, out of the 46 invited (43%), responded to the published author survey. Teachers found the submission-to-publication process "rigorous," "lengthy and detailed," "very time consuming"; one teacher said it was "very easy," "encouraging and supportive," "efficient," and "respectful of time"; another teacher said it was "difficult at first but got easier with experience." Several teachers noted satisfaction in their final published product ("at the beginning it is difficult, but it is rewarding to see the final product"; "the editing and feedback process made my lesson much stronger").

In response to being asked how they were personally impacted by the submission-to-publication process, several teachers cited a sense of accomplishment, while others ranged in their responses: "made me a better researcher and writer"; "[it] impacted me personally by giving me the confidence to submit more curriculum to *TeachEngineering* or to other publications. As well as, [sic] presenting my ideas to others"; "it helped [me] understand how to produce a quality activity"; "makes me, a teacher, feel empowered and confident in implementing more engineering practices"; "it has been the best learning experience I have had to produce high quality lessons that really impact students."

Noteworthy in terms of impact, 80% of the teachers either "strongly" (9) or "somewhat" (9) agreed that "after going through the *TeachEngineering* submission-to-publication process, [they] are more likely to integrate engineering concepts into [their] teaching.

Summary and Conclusions

The survey results suggest that the *TeachEngineering* resources and outreach boost teachers' confidence in their own use of engineering thinking and pedagogy in K-12 classrooms. Additionally, the *TeachEngineering* resources both impact teachers' subsequent teaching practices and increase their likelihood of teaching engineering in their classrooms in the future. The results also point out the need for broader exposure to the K-12 engineering curricular resources dozens of NSF grantees have created over the past decade, thereby capitalizing on NSF's sunk investment and on the authors wide-ranging applications of engineering pertinent to K-12 learning. The results suggest that broadening teachers' exposure is a critical element to broadening classroom impact of K-12 design thinking and pedagogy.

Acknowledgement

This work was funded in part by National Science Foundation grant no. EEC 1544495. However, these contents do not necessarily represent the policies of the NSF, and you should not assume endorsement by the federal government. IRB 15-0362