New Orleans JAZZED about Engineering Education

Paper ID #16715

Recruiting via Creation of STEM Solutions to Societal Problems

Prof. Alka R Harriger, Purdue University, West Lafayette

Alka Harriger joined the faculty of the Computer and Information Technology Department (CIT) in 1982 and is currently a Professor of CIT. For the majority of that time, she has been actively involved in teaching software development courses. From 2008-2014, she led the NSF-ITEST funded SPIRIT (Surprising Possibilities Imagined and Realized through Information Technology) project. Since October 2013, she has been co-leading with Prof. Brad Harriger the NSF-ITEST funded TECHFIT (Teaching Engineering Concepts to Harness Future Innovators and Technologists) project. Professor Harriger's current interests include application development, outreach to K-12 to interest more students to pursue computing careers, applying IT skills to innovating fitness tools, and wearable computing.

Prof. Bradley C. Harriger, Purdue University, West Lafayette

Brad Harriger has over 30 years of experience teaching automated manufacturing and has authored/co-authored several related articles. Professor Harriger has served in several leadership roles with Society of Manufacturing Engineers and the American Society for Engineering Education, and is a founding member of an international Aerospace Automation Consortium, serving on its steering committee for several years. He has invested over twenty-five years in the development and maintenance of a multimillion dollar manufacturing laboratory facility complete with a full scale, fully integrated manufacturing system. Professor Harriger has been a Co-PI on two NSF funded grants focused on aerospace manufacturing education and is currently a Co-PI on the NSF funded TECHFIT project, a middle school afterschool program that teaches students how to use programmable controllers and other technologies to design exercise games. Additionally, he co-organizes multiple regional automation competitions for an international controls company.

Susan Marie Flynn, College of Charleston

Susan Flynn works in the School of Education, Health and Human Performance at The College of Charleston. She is training students' in early childhood and elementary teacher education providing future educators with the skills and knowledge to infuse health and movement in the classroom. Prior to The College of Charleston, Flynn taught at Purdue University in Indiana for twelve years in the Department of Health and Kinesiology. She specializes in the areas of Adapted Physical Education; Fitness Education and Action-Based Learning. Flynn taught in the public schools outside of Toledo, Ohio as an Adapted Physical Education Specialist and in Maryland as a Special Education Teacher. More recently, she has been providing teachers the knowledge and skills to teach their students how to use technology to enhance fitness through the TECHFIT program.

Dr. Michael G Flynn, College of Charleston

Flynn has a PhD in human bioenergetics and a 30 year career of teaching and research in exercise physiology. Flynn has authored or co-authored over 80 refereed manuscripts and book chapters. He has received grants from NIH , American Heart Association, NSF and the American College of sports medicine.

Recruiting via Creation of STEM Solutions to Societal Problems

Abstract:

The literature is replete with studies that share many reasons why students, particularly women and minorities, choose specific fields of study. Among the top of these reasons is a desire to help people/society to make a (positive) difference in the world. The Teaching Engineering Concepts to Harness Future Innovators and Technologists (TECHFIT) project uses this approach to teach teams of middle school teachers how a combination of STEM skills can enable them to envision, design, and implement technology-supported fitness games to increase physical activity. The teachers, in turn, manage and deliver an afterschool program at their schools to teach their students how to combine STEM skills and use supplied technology to innovate exergames.

The paper and presentation will share details about the content of the TECHFIT program as well as share a sampling of the exergames created by teacher teams and student teams. Anecdotal feedback that describes TECHFIT's impact on both groups will be shared as well.

Background

Students contemplating college majors would benefit from knowing how likely those majors are to lead to successful careers, ones that will offer them a comfortable lifestyle, higher job security, and increased personal satisfaction. The Glassdoor Team documented the 25 highest paying jobs in demand by employers, and nearly half on the list are IT-related. [1] U.S. News reports on the 100 best jobs, and of their top 20, all are in the medical domain with the exception of three IT-related jobs and one math-related job. [2] Engineering careers are also good career choices. Unfortunately, when comparing the demographics of the general population against the people studying IT/engineering or in IT and engineering careers, there are gender and ethnicity gaps.

According to the National Center for Women and Information Technology, over 50% of bachelor's degree recipients were women, but less than 20% of computer science bachelor's degrees were earned by women. [3] The U.S. Census Bureau reported in 2011 that women made up only 13% of engineers and 27% of computing professionals. [4] Similarly, certain minorities (Blacks, Hispanics, Native American) are also underrepresented in the STEM workforce. [4]

Although gender and ethnicity underrepresentation is a commonly-recognized problem, the goal of this paper is to share some ideas that will begin to make a positive impact. Edutopia advises that exposing young girls to STEM, encouraging their participation in special programs, supporting learning opportunities in the community, serving as a mentor, and simply becoming better informed will help get girls into STEM. [5] The Girl Scouts report stated that girls want to change the world and help people, so if they could better understand the link between STEM careers and this goal, more are likely to pursue STEM study. [6] Additional recommendations include having representative teachers that are informed about STEM to stimulate student interest in these fields. [7]

The goal of TECHFIT is to spark STEM interest in middle school children, especially underrepresented minorities. The approach employed is to demonstrate the positive impact that

information and technology have on society by providing solutions to big problems. The problem area addressed by TECHFIT is physical inactivity. By equipping the middle school students with the knowledge, skills, materials and tools to innovate technology-based fitness games that will get people moving and having fun, the TECHFIT team helps them realize the value of pursuing study in STEM. Although the middle school students are the primary focus, the TECHFIT team works directly with teams of middle school teachers, who in turn deliver afterschool programs to their students based on what they learned from the TECHFIT team.

As of December 2015, TECHFIT has offered four sets of six-day professional development (PD) programs to a total of sixteen teacher teams comprised of 44 middle school teachers in two different states: Indiana and South Carolina. The Indiana program is offered at the Purdue University campus in West Lafayette, Indiana. The South Carolina program is offered at the College of Charleston in Charleston, South Carolina. Nearly 400 students have completed the TECHFIT afterschool program at fifteen different schools.

The teacher PD programs are offered in the summer months at two different institutions. Teacher teams typically attend the PD program in their own state; however, in 2015 one group of teachers travelled to the other state due to a schedule conflict with the program in their state.

Teacher/School Selection

In order for a school to be considered for TECHFIT, a teacher team of two to five teachers in different subjects must apply for consideration. An ideal team would include teachers in physical education and technology education; however, there have been successful teams without expertise in both subject areas. The applications are submitted using an online tool. In addition to basic demographic information, the application includes several short answer questions.

There is a small committee of reviewers that evaluate the individual applications using a web tool that preserves the anonymity of each applicant, allowing the review of the short answer responses to be as unbiased as possible. The web tool scores each applicant by combining the reviews of the committee members and public information about the schools, such as size of school, percentage of underrepresented minorities, and underserved status. The average scores of each teacher team determine each school's score. The applicants of the top scoring schools are invited to submit required paperwork to reserve their spots. In the event a school drops out, an invitation is issued to the next ranked teacher team until all available spots are filled.

Teacher PD

Each teacher is expected to complete the entire six-day residential program. Fitness activities called "Brain Blasts" are interspersed throughout the day, every day of the program. [8] One of the reasons is to help the participants experience a variety of activities that they might consider in the design of their own exergame innovation. Another reason is to help them experience the documented benefit of breaking up long, academic instruction with movement to keep the brain cells more active, which results in being able to cover more content that is better retained by the participants. Pica confirms that for young children, "physical activity activates the brain much more so than doing seatwork." [9] In addition to the STEM and fitness instruction offered by the

TECHFIT team, external industry and academic experts are invited to share related information with the teachers during the daily lunch and learn.

Each teacher team receives a technology toolkit valued at $4500. Much of the materials are provided through donations of technology by Phoenix Contact and Balluff Inc., two industry partners of TECHFIT. [10] [11] The "brain" of the exergame is the Nanoline microcontroller, which may be programmed using a flowcharting programming language freely available from Phoenix Contact's website. [12]

Each day of the program, the teachers are assigned homework to help them practice an important lesson taught that day. The essignments online assignment submission system is used to collect the homework. [13] Everyone's homework submission is presented and reviewed at the start of the subsequent day, so everyone can benefit from different ideas as well as provide their own reaction. Most of the essential STEM content is covered within the first three days, so that the teacher teams can begin to innovate their own exergame for demonstration on the fifth day. Table 1 identifies the daily topics covered and homework assigned.

Table 1: PD Topics

Day	Topics Covered	Homework
1-Mon	• Introductions • Engineering Design Practice (EDP) • Definitions: STEM & fitness • Critical thinking: logic for designing exergames • Review commercial exergames • Identify TECHFIT toolkit components • Scratch animation • Play exergame without technology	1. Scratch animation of some type of fitness activity 2. Suggest how technology can be integrated into the sample exergame
2-Tues	• Play Scratch animation homework • Review EDP • Flowchart programming • Create simple exergame flowchart program, test with simulator • Basic electricity & safety • Assemble TECHFIT toolkit • Download flowchart program to controller • Play exergame with technology	1. Team develops animation to describe simple exergame 2. Individual homework to create simple exergame with specific electronic components
3-Wed	• Play Scratch animation homework • Compare/contrast simple exergame development to commercial exergames • Incorporate user input into programs • Employ randomness and choice into games • Use spreadsheets to track fitness data • Enhancing user interface (HMI)	1. Team brainstorms 2 possible games for possible implementation; create Scratch animation for at least one game

Day	Topics Covered	Homework
4-Thurs	• Review game design concepts • Each team presents their game ideas to get feedback from the group • Teams work on refining the Scratch animation, Excel worksheets to track data, and nano program • Teams present game concepts without technology to practice game play and identify issues and get feedback	1. Team develops logic, identifying inputs, outputs, data tracked, role of random numbers, game options for players, and materials required
5-Fri	• Review Afterschool program expectations and materials/resources available • TECHFIT staff distribute materials to each team • Teams implement their exergames and accompanying animations, slideshows • Everyone plays each team's exergame	1. Team develops tentative afterschool program schedule based on unique needs of their schools
6-Sat	• Each team presents afterschool implementation plans, anticipated issues • TECHFIT graduation	

Teachers are provided with a 230-page, lab-based workbook that includes lessons over the PD classroom content. In addition to step-by-step, illustrated instructions, each lesson maps the content to state and national standards for grades 6-8. This feature allows teachers to integrate some of what they learned into their regular school day classes.

The Afterschool Program

The goal of the TECHFIT afterschool program is for the teacher teams to teach their students the same things that they learned in the summer PD program. An 82-page Afterschool Curriculum workbook is also provided as a starting template. The teacher teams use that and consider their school schedules to customize their own afterschool program.

The minimum afterschool program is expected to meet twice a week over a ten-week period. Like the teacher PD, every afterschool meeting includes fitness activities interspersed with the STEM content. The technology toolkit that was provided to each teacher team is the same one used by the students in their afterschool programs. Table 2 lists the recommended agenda for the STEM coverage.

Table 2: Afterschool Schedule

Week	Topics Covered
1	• Introduction to TECHFIT
2	• Using software tools • Scratch
3	• Introduction to Flowchart Programming • Nano Navigator Programming

Week	Topics Covered
4	• Introduction to Electronic Components and Safety • Advanced Nano Navigator Programming
5	• Exergame Brainstorming • Exergame Refinement
6	• TECHFIT team assignments • Project Preparation and Team Progress Reports
7	• Project Preparation & Progress Reports by 3 teams: Science & Lifestyle, Math & Assessment, Build & Technology • Exergame Demonstration
8	• Project Preparation & Progress Reports by remaining 2 team: Promotion & Graphics, Community & Sustainability
9	• Project Demonstration, Refinement
10	• Dress Rehearsal • School Assembly

The culminating activity of the afterschool program at each school is to attend the showcase event at the host institution in their state. Each school presents their afterschool experience, shows a Scratch animation to explain game play, and demonstrates actual playing of their exergame. A team of judges evaluates the presentations and identifies the outstanding efforts by each team as well as names the overall winner. Figure 1 shows a winning team's exergame.

Figure 1 2015 winning team demonstrates playing of their exergame

Participant Feedback

TECHFIT collected participant feedback via pre-program and post-program surveys. A subset of the evaluator's analysis of this data collected from the 22 teachers in the 2015 cohort and 157 students in the 2014 cohort follows. [14]

All teachers agreed or strongly agreed that TECHFIT enhanced their understanding of how science, technology and engineering concepts can be applied to real-world problems. They also agreed that the program enhanced their understanding of the relevance of technology to fitness. More than 90% also agreed that TECHFIT enhanced their understanding of how mathematical concepts can be applied to real-world problems. All teachers agreed that the afterschool program should provide their students with opportunities to apply math and science skills to solve real-world problems. Most importantly, all teachers felt that the afterschool program should increase

their students' interest in technology and engineering careers.

Over 90% of the students agreed or strongly agreed with the following statements:

- Participating in TECHFIT increased their interest in a science, technology or engineering careers.
- TECHFIT enabled them to see how different subjects are related.
- TECHFIT taught them about what professionals do with technology.

Some anecdotal feedback from teachers follow: [15]

- A seventh grade social studies teacher at a Title I, rural, middle school said, "TechFit was a remarkable experience for our students and staff. Not only did it provide real-life skills in the STEM field, but it also demonstrated to our students what remarkable tasks they can accomplish when they are truly dedicated and engaged in a project."
- An instructional coach at a Title I, middle magnet school said, "We are loving it. Truly a STEAM, student centered program."

Some comments from students follow: [15]

- A fifth grade student from a Title I intermediate school said, "About a week before this started, my mom asked me what I wanted to do when I grow up. And I said, 'I don't really know.' And I came here, and I was like, 'I want to do this. I want to program.'"
- A seventh grade student from a Title I, middle magnet school said, "I thought it was nice to use things that I learned in school to do something important for our team."

When the students were asked if the TECHFIT afterschool program changed their career goal, several said they now want to be an engineer, programmer, and/or work with technology. When asked if the program changed their course selection in school, several mentioned enrolling in technology, science, and/or computing courses. When asked if TECHFIT impacted their course performance, many stated improvements in math, science, and technology courses.

Conclusion

This paper shared a successful approach for teaching teams of middle school teachers how a combination of STEM skills can enable them to innovate solutions to big, societal problems, in the case of TECHFIT designing and implementing exergames to address the issue of physical inactivity. The teachers used what they learned to manage and deliver an afterschool program at their schools to show their students how STEM skills can be applied in fun and useful ways. Topical outlines for both the teacher professional development program and student afterschool program were included to show the breadth of STEM coverage. Finally, assessment results from participant surveys showed that both the teacher and student groups responded favorably to the TECHFIT approach. Showing teachers and students that STEM can be fun, impactful, and doable does work!

References

[1] Glassdoor Team, "Glassdoor," 17 February 2015. [Online]. Available: https://www.glassdoor.com/blog/highest-paying-jobs-demand/. [Accessed 31 January 2016].

[2] U.S. News & World Report, "The 100 Best Jobs," 2016. [Online]. Available: http://money.usnews.com/careers/best-jobs/rankings/the-100-best-jobs. [Accessed 31 January 2016].

[3] National Center for Women in Computing, "By the Numbers," National Center for Women in Computing, Boulder, CO, 2015.

[4] L. C. Landivar, "Disparities in STEM Employment by Sex, Race, and Hispanic Origin," U.S. Census Bureau, Washington, 2013.

[5] K. D. Purcell, "5 Ways to Get Girls into STEM," Edutopia-George Lucas Educational Foundation, 2015.

[6] Girl Scout Research Institute, "Generation STEM: What Girls Say about Science, Technology, Engineering, and Math," Girl Scouts of the USA, New York, NY, 2012.

[7] G. M. Faitar and S. L. Faitar, "Teachers' Influence on Students' Science Career Choices," *American International Journal of Social Science*, vol. 2, no. 5, pp. 10-16, July 2013.

[8] S. Flynn, "Brain Blasts," 2016. [Online]. Available: http://www.fit2bsmart.com/brain-blasts.php. [Accessed 30 January 2016].

[9] R. Pica, Early Elementary Children Moving and Learning: A Physical Education Curriculum, St. Paul, MN: Redleaf Press, 2014, p. 8.

[10] Phoenix Contact, 2016. [Online]. Available: https://www.phoenixcontact.com/online/portal/us. [Accessed 31 January 2016].

[11] Balluff Inc., "Balluff Worldwide," 2016. [Online]. Available: http://www.balluff.com/balluff/MUS/en/home.jsp. [Accessed 31 January 2016].

[12] Phoenix Contact, 2016. [Online]. Available: https://www.phoenixcontact.com/nanoline. [Accessed 31 January 2016].

[13] A. Harriger and K. Lutes, "An Online Assessment Submission System to Collect Participant Deliverables," STEM Learning and Research Center, Washington, DC, 2010.

[14] Evaluation Team of PurdueA University, "Evaluation of TECHFIT Professional Development Program: Summer 2015," PurdueA University, IndianaX, IndianaX, 2015.

[15] TECHFIT, "TECHFIT Testimonials," 2016. [Online]. Available: http://techfit.tech.purdue.edu/TECHFITFeedback.aspx. [Accessed 7 March 2016].

[16] D. Grove, "Middle school program combines fitness, technology and competition," Primeland LLC, West Lafayette, 2015.