2018 ASEE Annual Conference & Exposition
Paper ID #21830

RAMP: Summer Bridge Program for Female High School Students

Dr. Jiahui Song, Wentworth Institute of Technology

Jiahui Song received her B.S. in Automation and M.S. in Pattern Recognition & Intelligent Systems from Southeast University. She received her Ph.D. in Electrical and Computer Engineering from Old Dominion University. She is currently an Associate Professor in the Department of Electrical Engineering and Technology at Wentworth Institute of Technology.

Dr. Gloria Guohua Ma, Wentworth Institute of Technology

Gloria Ma is an Associate Professor in the Department of Mechanical Engineering and Technology. She has been teaching robotics with Lego Mindstorm to ME freshmen for several years. She is actively involved in community services of offering robotics workshops to middle- and high-school girls. Her research interests are dynamics and system modeling, geometry modeling, project based engineering design, and robotics in manufacturing.

RAMP: Summer Bridge Program for Female High School Students

Abstract

RAMP is a six-week, summer bridge program at our institute to help students explore STEM careers and navigate the transition from high school to higher education. Over the past several years, RAMP has helped introduce over 150 youth to college life by connecting them with peers, enabling them to participate in skills-based workshops and hands-on projects, connecting them to alumni and other industry mentors, and helping them to become immersed in campus life prior to the start of their freshman year of college. In recently two years, more women students are recruited to the program, a unique mini program "RAMP for High School Girls is designed. The objective for this program is to expose students to various STEM disciplines.

The six-week mini RAMP program is organized as modules. Each week the female students explore a different STEM discipline. The Mechanical and Electrical modules are presented in this paper. An entrance survey and an exit survey were conducted to collect data right before and after students completed the projects to evaluate the content of the workshops. 32 rising juniors/senior female high school students participated in the RAMP for High School Girls program in the past two years. The survey shows 6.25% students knew some/a lot about Electrical Engineering in the entrance survey, while 56.25% of the students knew some/a lot about Electrical Engineering in the exit survey. 6.25% students thought they knew some/a lot about Mechanical before the workshop, and 56.25% students thought they knew some/a lot about Mechanical Engineering after the workshop. Students reflected that they enjoyed the experience very much and found the workshops to be extremely helpful in helping them to further identify their college interests and majors.

Introduction/Background

Nowadays, more and more scientists, engineers and innovators are needed to succeed in the global competitive economy environment. As a result, this requires quality science, technology, engineering and mathematics (STEM) education. However, few American students pursue education and training in the STEM fields. After noticing this challenge, the whole STEM society has made great efforts to increase STEM-related activities, which have the potential to promote collaborative learning and inquiry as well as to contribute to the development of the 21st century skills [1]. The US government also realized the shortage of STEM workforces. It initiated the "Educate to Innovate" program to increase student participation in all STEM-related activities. The ultimate objective of these activities is to encourage more students to choose an education in the STEM fields and pursue a STEM-related career in the future [2].

Getting more students involved in the STEM education is already a challenge. Attracting more female students into the STEM fields can be even harder. Statistics data show that there is a big gender gap in the STEM fields in workplaces. It has been found that women make up 46% of the workforce but hold only 24% of jobs in STEM fields [3]. Many institutions and organizations have realized this challenge and provided various activities to promote female students into the

STEM fields [2]. In addition, different strategies were developed to recruit and retain students in the STEM education [4-5]. Creating quality, attractive STEM programs [6] and using peer influence to motivate high school girls into the STEM fields [7-8] appears to be effective ways to retain female students in STEM.

Since 2011 our institute has begun to organize a six-week summer bridge program targeted to incoming freshmen from the city school system to help them smoothly transit from high school to college. In recent years rising juniors/seniors are invited to the program too. More female students have participated in the program since 2016, and most of them are rising juniors/seniors. A mini program "RAMP for High School Girls" is then created to expose high school girls to STEM fields. They not only participate in regular RAMP program, but also spend four hours a week, six weeks to participate in the mini program "RAMP for High School Girls".

The main goal of the mini program is to expose female students to various STEM disciplines. Therefore, the mini program is organized as modules. There are 6 different modules: Biomedical, Civil, Electrical, Mechanical Engineering, Computer Science, and Industrial Design. The high school girls explore all 6 STEM/Design modules over six weeks. Each week, they explore a different STEM workshop for two hours per day and twice a week. These workshops are conducted by faculty from different departments. In each workshop, besides overviewing the field and major, faculty's own experience in the field and teaching, career options within major/field, hands-on activities are also introduced to the students.

This paper describes our experience of conducting the mini RAMP program to expose/attract high-school girls into the STEM fields. This paper presents our study with the Mechanical and Electrical workshops, including preparation, implementation, survey data, observations, and findings.

Workshop Implementation

Laboratory exercises play an important role in engineering education [9-11]. They provide the opportunity for students to work on modern machines, tools used in industry [12]. Therefore, in our workshops, we focus on hands on activity using modern machines and tools.

<u>Mechanical workshop</u>

There were two experiments introduced in mechanical lab: Heat Engine and tensile test, which represent two different areas of Mechanical engineering: Thermo-fluid and Solid Mechanics.

Lab 1: Heat engine

In this experiment, different thermodynamic processes were discussed: isothermal, isobaric, and isovolumetric. The objective of this experiment was threefold: i) identify real isothermal and isobaric thermodynamic processes using a real heat engine; ii) create a cyclic process using the

Pasco heat engine and develop the pressure-volume (P-V) diagram; and iii) experimentally measure the work done through the entire cyclic process.

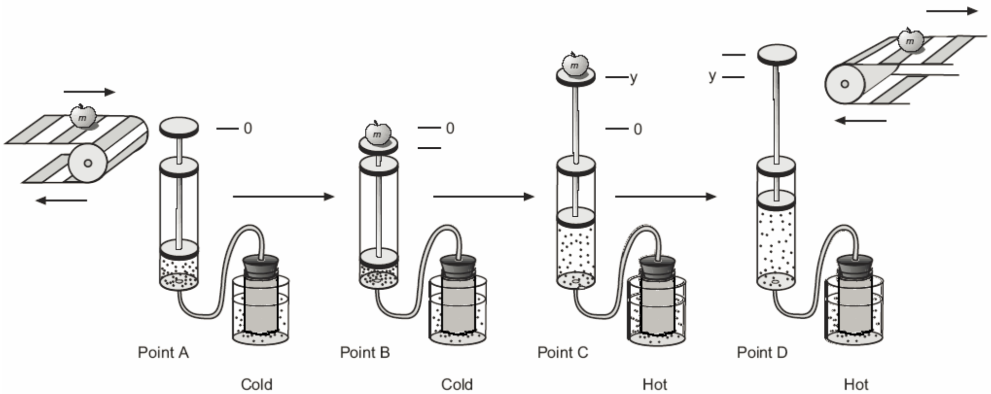


Figure 1: Heat Engine experiment (Adapted from PASCO Scientific instruction manual for Heat Engine / Gas Law Apparatus, document #012-06014C.)

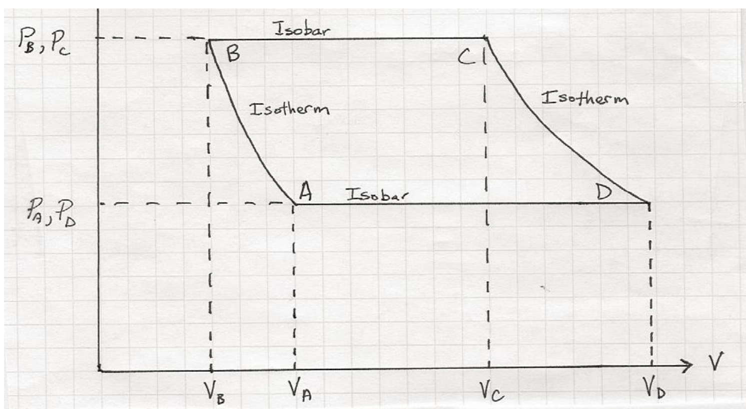


Figure 2: P-V diagram

The P-V Diagram looks something like Figure 2. Two legs of the cycle are isotherms, and two are isobaric. The area inside the p-v diagram is the thermodynamics work the heat engine does over one cycle.

Lab 2 Tensile test

In this experiment, the properties of materials were discussed, as well as the experimental way to obtain them and how to use them. The objective was twofold: i) obtain the data necessary to generate a stress vs. strain diagram of two different materials; and ii) use this information to verify some important properties such as yield strength, ultimate tensile stress, and modulus of elasticity.

For structural applications of materials, such as bridges, pressure vessels, ships, and automobiles, the tensile properties of the metal material set the criteria for a safe design. The tensile test lab was confined to test the tensile properties of two specimens: 6061 T6 aluminum and 1018 cold rolled steel. This test was a destructive method, in which a specimen was subjected to an axial load. Figure 3 and Figure 4 show the tensile test with Instron machine and the broken specimen.

Figure 3: Tensile test with Instron machine

Figure 4: broken specimen

For analytical purposes, a plot of stress (σ) versus strain (ε) was constructed during a tensile test experiment. the properties then can be identified: Ultimate stress, Yield stress, Modulus of Elasticity, etc. A sample stress-strain curve is showed below.

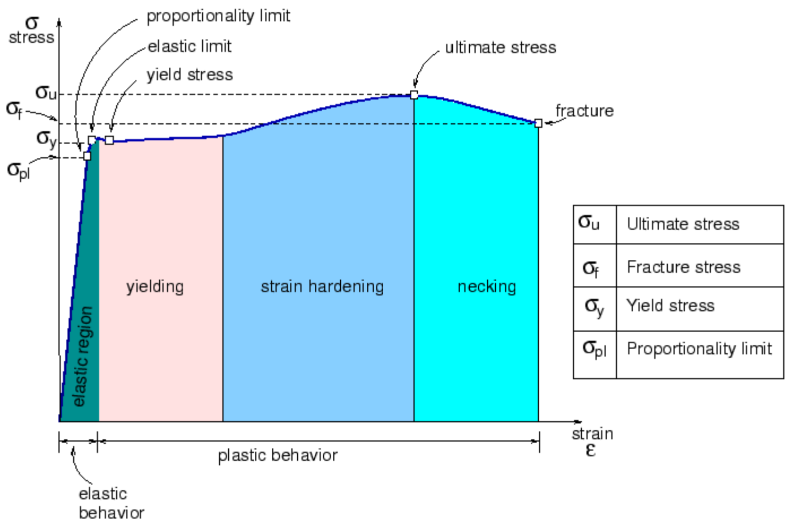


Figure 5. Various regions and points on the stress-strain curve.

Electrical workshop

The objective of Electrical workshop was to expose students to Arduino microcontroller to encourage student engagement by a fun project-----Autonomous Vehicle [12]. The project included 2 sequential labs: Lab 1 Pulse Width Modulation, and Lab 2 Arduino Pulse Width Modulation. This workshop included both software and hardware. Students were exposed to coding (loops, conditionals, and debugging), wiring, oscilloscope, DMM, function generator, and DC power supply use.

Lab 1 Pulse Width Modulation: the students were introduced to the basic benchtop instrumentation as used a function generator, oscilloscope, digital multimeter, and power supply. The challenge was to generate pulse-width modulation (PWM) periodic square waves to control a continuous stepper motor. This exposed the students to basic electrical engineering concepts of time-course signals, voltages, frequency and manipulations of periodic signals. Use of the bench top instruments and observation of how their different signals would control the motor allowed the students to develop some insight and confidence [12].

Lab 2 Arduino Pulse Width Modulation: instead of using the bench top instrument of a function generator to make the PWM signal, the students needed to write software on an Arduino microcontroller. With software and the microcontroller board, the students generated the same PWM signals that they had previously made with the function generator. This lab exposed students to the process of writing computer programs, downloading to hardware, running and testing that hardware. The trial and error experimentation and control of the motor allowed development of insight and confidence [12].

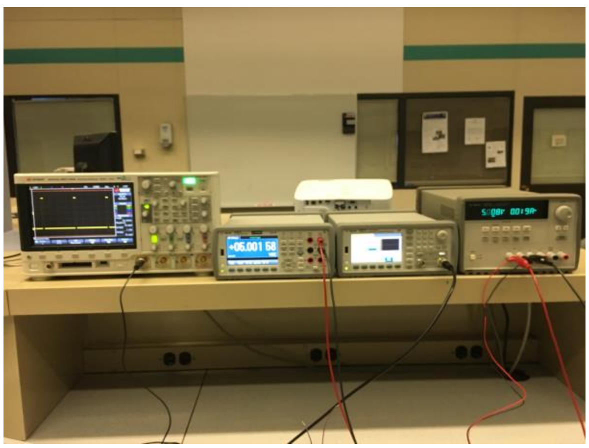


Figure 6. Square wave generated and measured by bench devices

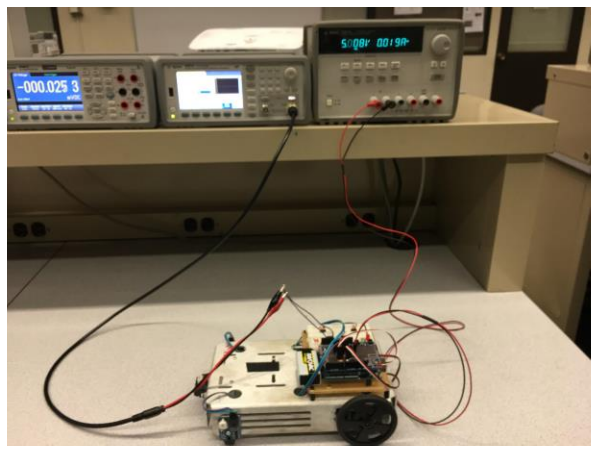


Figure 7. Hardware connection of autonomous vehicle

Survey Questions

An entrance survey and an exit survey were conducted to collect data right before and after students completed the projects to evaluate the content of the workshops. 32 female students participated in the RAMP for High School Girls program in the past two years and all of them took the surveys. Following are the questions we asked students in the entrance and exit survey:

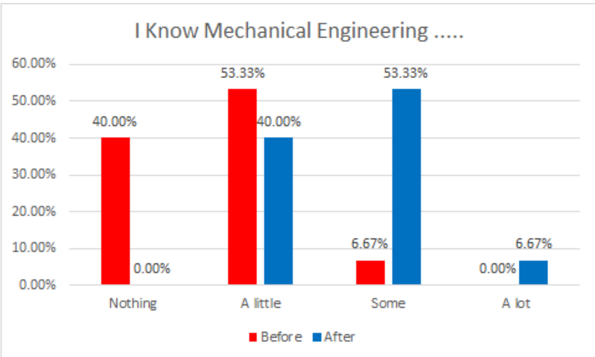
Table 1: Survey Questions

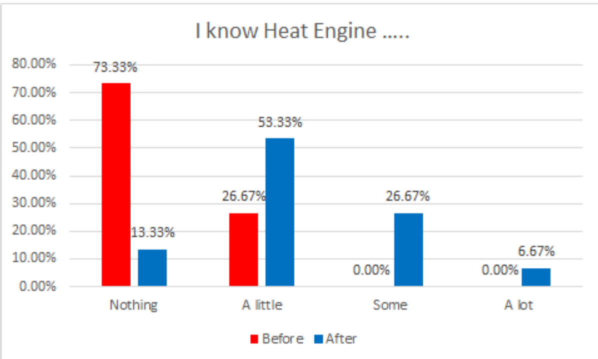
Mechanical Workshop	**Electrical Workshop**
1. I know…. (a) Nothing about Mechanical Engineering (b) A little about Mechanical Engineering (c) Some about Mechanical Engineering (d) A lot about Mechanical Engineering	1. I know…. (a) Nothing about Electrical Engineering (b) A little about Electrical Engineering (c) Some about Electrical Engineering (d) A lot about Electrical Engineering
2. I know… (a) Nothing about Heat Engine (b) A little about Heat Engine (c) Some about Heat Engine (d) A lot about Heat Engine	2. I know… (a) Nothing about Microcontroller (b) A little about Microcontroller (c) Some about Microcontroller (d) A lot about Microcontroller
3. I know… (a) Nothing about the strength of materials (b) A little about the strength of materials (d) Some about the strength of materials (d) A lot about the strength of materials	3. I know… (a) Nothing about computer programming (b) A little about computer programming (c) Some about computer programming (d) A lot about computer programming

Survey Results

The survey results are shown in Figure 8-11.

Mechanical workshop





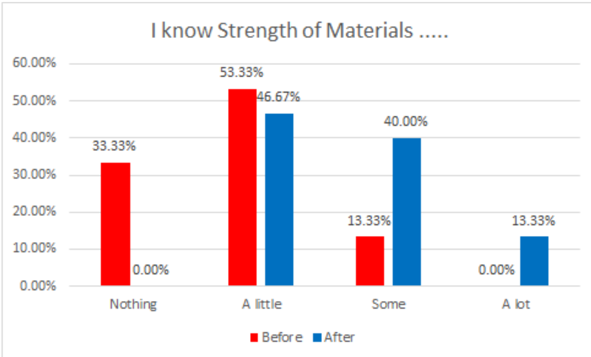


Figure 8: Survey result for Mechanical labs

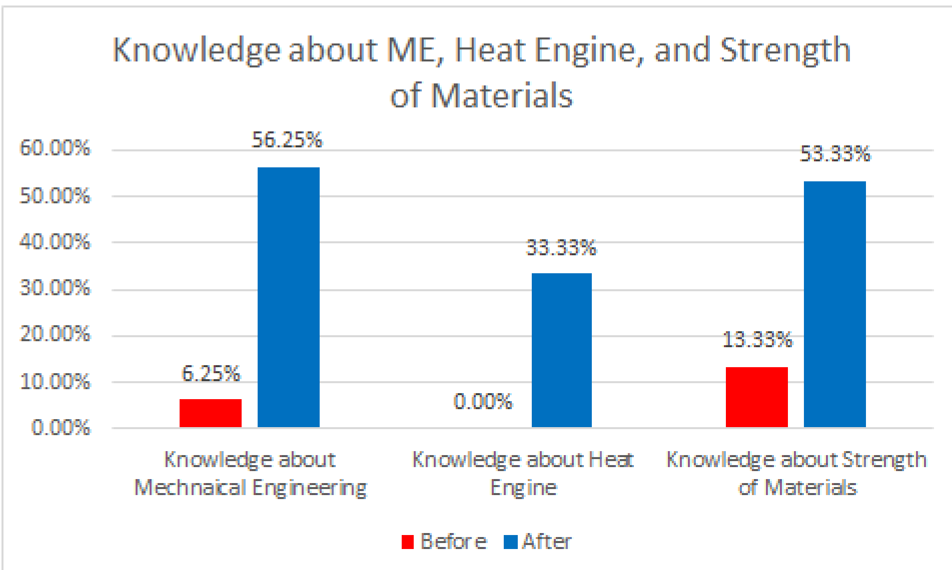
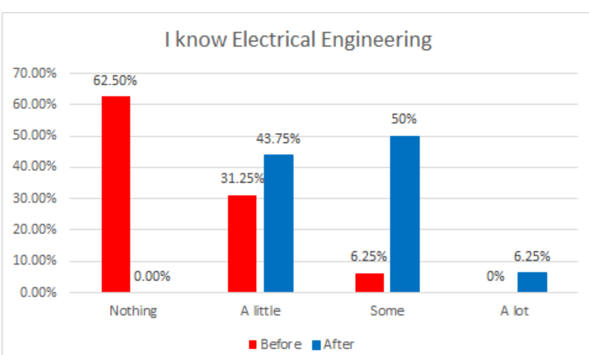
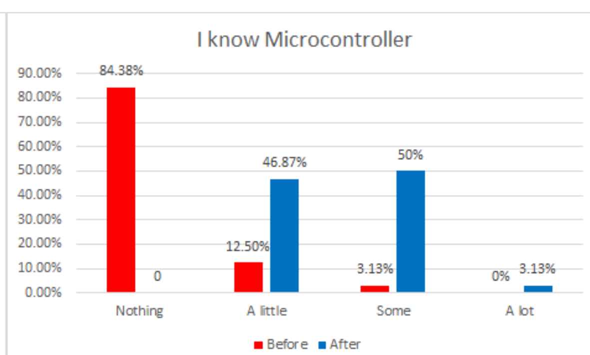


Figure 9 Survey Results: Knowledge about ME, Heat Engine, and Strength of Materials

<u>Electrical workshop</u>





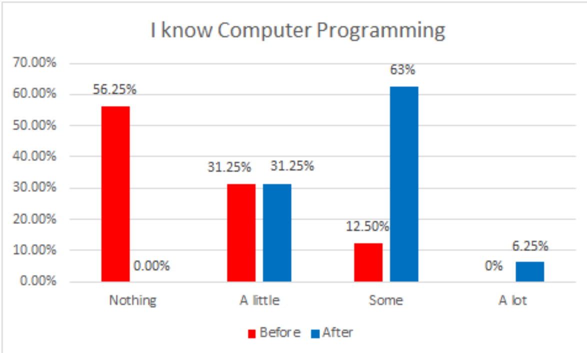


Figure 10 Survey results for Electrical labs

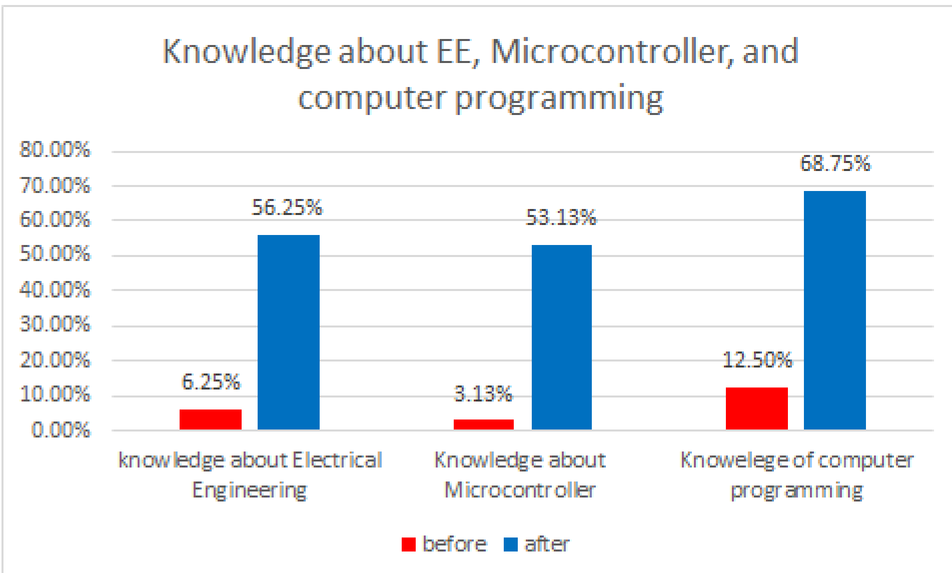


Figure 11 Survey results: Knowledge about EE, Microcontroller, and Computer Programming

From the survey results we can see that many students gained some knowledge about Mechanical and Electrical Engineering after these workshops. Before Mechanical Engineering workshop, 6.25% of the students knew some/a lot of Mechanical Engineering, while after the workshop, 56.25% of the students thought they knew some/a lot of Mechanical Engineering. Before and after Electrical Engineering workshop, students who thought they knew some/a lot of Electrical Engineering also increased from 6.25% to 56.25%. Students also reflected that they enjoyed the experience very much and found the workshops to be extremely helpful in helping them to further identify their college interests and majors.

Conclusions

"RAMP for High School Girls" program is motivated by exposing the high-school girls to STEM fields, boosting students' interests and giving them more hands-on experience. It could also recruit new students into our institute, as well as fulfilling our long-term objective of recruiting more female students into the STEM-related career.

Mechanical and Electrical workshops were presented in this paper. The survey results assured us that the workshops were interesting to the students and proper topics were selected. It also indicated that students enjoyed hands-on activities.

The experience gained from this mini RAMP program will certainly help us to be more prepared and creative in organizing similar workshops in the future. We believe these experiences would also benefit other educators and researchers with the common goal of increasing the number of female professionals in the STEM fields.

After completing the mini RAMP program, students reflected that the workshops were extremely helpful in helping them to further identify their college interests and majors. Our future direction would be to track the number of students who enroll in STEM fields after they finish this "RAMP for High School Girls" mini program.

References:

[1] Sahin, A., Ayar, M. C., and Adiguzel, T., "STEM Related After-School Program Activities and Associated Outcomes on Student Learning", *Educational Sciences: Theory and Practice*, 14(1), 309-322, 2014.

[2] Ma, G., and Ma, L., "Retaining Female Students in a Robotics Program", *Proceedings of the 2017 American Society for Engineering Education conference and exposition*, 2017.

[3] Crowe, S., "Robotics playing a bigger role in STEM education", *Robotics Business Review*, May 27, 2005. URL: https://www.roboticsbusinessreview.com/rbr/robotics_playing_bigger_role_in_stem_education, accessed March 13, 2018.

[4] Zywno, M. S., Gilbride, K. A., and Gudz, N., "Innovative outreach programs to attract and retain women in undergraduate engineering programs", *Global Journal of Engineering. Education*, 4(3), 293-302, 2000.

[5] Doerschuk, P., Liu, J., and Mann, J., "INSPIRED broadening participation in computing: Most successful strategies and lessons learned", *In Frontiers in Education Conference (FIE)*, IEEE (pp. T2H-1), 2010.

[6] DeBartolo, E., and Bailey, M., "A continuous series of outreach programs to recruit young women to engineering. Age", *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition*, 2005

[7] Robnett, R., "The Role of Peer Support for Girls and Women in STEM: Implications for Identity and Anticipated Retention", *International Journal of Gender, Science and Technology*, 5(3), 232-253, 2013.

[8] Akl, R. G., Keathly, D., and Garlick, R., "Strategies for Retention and Recruitment of Women and Minorities in Computer Science and Engineering", *Innovations 2007: World Innovations in Engineering Education and Research*, 2007.

[9] Feisel, L.D. and Rosa, A.J., "The role of the laboratory in undergraduate engineering education”, *Journal of engineering education*, pp. 121-130, January 2005.

[10] Thomas, J.W., "A review of research on project-based learning", *California: The Autodesk Foundation*. URL: http://www.bie.org/images/uploads/general/9d06758fd346969cb63653d00dca55c0.pdf, March, 2000. Accessed March 13, 2018.

[11] Waks, S. and N. Sabag, N., "Technology Project Learning Versus Lab Experimentation", *Journal of Science Education and Technology*, Volume 13, issue 3, pp. 333-342, September 2004.

[12] Song, J. and Ma, G., "Different Lab Formats in Introduction to Engineering Course", *Proceedings of the 2017 American Society for Engineering Education conference and exposition*, 2017.