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Using a Service-Learning Pedagogy to Improve Student Engagement

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Using a service-learning pedagogy to improve student engagement

Abstract

Service-learning is a method of teaching that integrates community service into an academic course through applied learning to enrich the educational experience of students and meet the needs of the community. In this paper, we describe the integration of service-learning into an undergraduate industrial engineering course.

Over the past three years, students in the course have worked with four community partners to complete service-learning projects. The community partners have included a high school, community library, local farm, and an assistive technology center. Students worked directly with community partners to improve operations and ergonomics within their facilities. Through the projects, students gained a deeper understand of the course content, as well as an appreciation of how industrial engineering can be applied to improve the community.

In this paper, the structure of the service-learning project within the course is detailed. Quantitative and qualitative data from student participants are examined to explore the benefits of incorporating service-learning into the industrial engineering classroom. Recommendations for implementing service-learning in the classroom are also presented.

Introduction

The pedagogy of service-learning is an effective way to connect college students with community partners in an effort to improve local and global communities[1]. Service-learning projects is linked with an academic course, and students are able to gain information about their course topic while at the same time helping to fill a community need. Service-learning combines community engagement, critical reflection, reciprocity, and public dissemination in an effort to create effective partnerships[2-3].

Studies have shown that service-learning is a high-impact practice that increase student effort in a course through the process of solving real-world problems[4-6]. The application of service-learning to the classroom allows for students to participate in "active, challenging, learning experiences, experience diversity, interact with faculty and peers about substantive matters, receive more frequent feedback, and discover the relevance of their learning through real-world experiences."[2] Additional benefits of service-learning have been found related to students' emotional development, communication and interpersonal skills, and academic motivation[10-14].

Within the engineering academic domain, a variety of approaches have been adopted[12-13]. The text *Service-Learning: Engineering in Your Community*[14] includes information useful to instructors looking to design and develop service-learning in engineering courses and

curriculum. The application of service-learning pedagogy to ABET student outcomes has also been explored[15-16]. While many engineering education initiatives focus on freshman or capstone experiences[17-20], service-learning appears to be an effective means to reach the mid-career student in their sophomore or junior years[21-22].

Course Structure

The course in which service-learning was implemented is IE 3123, Industrial Ergonomics. This course is a required course in the industrial engineering curriculum at Mississippi State University, and has included a service-learning component for the past three years. The majority of students take the course during the first semester of their junior year, and enrollment averages 45 students. The topics taught in the course include work measurement, physical ergonomics, and cognitive ergonomics. The course learning objectives were as follows:

- Utilize problem-solving tools to select areas for improvement, collect and analyze data related to those areas, and develop solution strategies in work environments.
- Analyze, design/re-design ergonomically correct workplaces using ergonomic principles of motion economy, anthropometry, manual material handling, and workstation design.
- Understand the principles of performance rating and allowances and apply them to time study in order to develop standard times.
- Apply work sampling to determine utilization, allowances, and standard times.
- Understand the impact of work task design on work and operator performance.
- Understand human capacities and limitations and apply that information to the design, development, and evaluation of systems.

The student service-learning projects have covered a wide variety of course topics. However, the following topics are applied to the community partners' needs most readily: line balancing, time study, material flow, facility layout, posture assessment, lifting safety, and anthropometry.

The course has an "S" designation associated with it, as it is formally recognized as a service-learning course by the university. This designation communicates that students in the course will apply the course material in a meaningful way to fill a community need. The overall project accounted for 30% of the course grade. This included five deliverables: reflective journal (10%), preliminary operations analysis report (30%), preliminary design recommendations report (30%), final technical report (10%), and project showcase (20%).

The journals were done individually by each student, and the other deliverables were completed by teams of 5 to 6 students. Students were assigned to groups by the course instructor, and each student completed a peer evaluation of their teammates at the end of the semester.

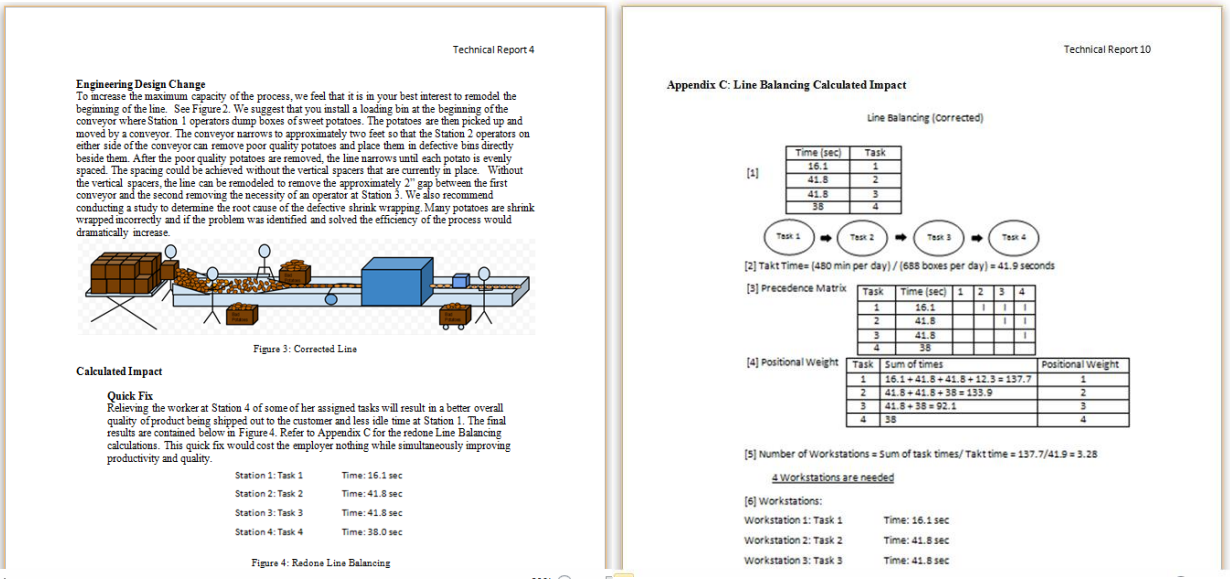
Community partners were identified through the Center for the Advancement of Service-Learning Excellence (CASLE, www.servicelearning.msstate.edu) at Mississippi State University. The CASLE staff worked with the course instructor to identify community partners

that had operations that aligned with the course objectives. For the IE 3123 course, this included partners that had an operation with a sequential process (for operations analysis) as well as a manual labor component (for ergonomics assessments).

Community Partner #1

The first semester of using service-learning in IE 3123, the community partner was N&W Farms, a sweet potato farm and distributor. The company has a vast operation which includes planting, harvesting, storing, sorting, packaging and shipping sweet potatoes. Student teams were assigned a specific operation with the packaging facility. Each student team had to develop at least one operations recommendation and one ergonomics recommendation based on their observations and collected data.

Figure 1 shows examples of student work from this first semester, and Figure 2 shows a student team presenting their work at our end-of-semester project showcase. Working with community partner #1 had a lot of benefits: multiple operations, industrial setting, and a highly cooperative workforce. Some of the disadvantages included distance to reach the facility (approximately 60 miles), limited data collection time, seasonality of the operation, and low connection to the community.



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Engineering Design Change

To increase the maximum capacity of the process, we feel that it is in your best interest to remodel the beginning of the line. See Figure 2. We suggest that you install a loading bin at the beginning of the conveyor where Station 1 operators dump boxes of sweet potatoes. The potatoes are then picked up and moved by a conveyor. The conveyor narrows to approximately two feet so that the Station 2 operators on either side of the conveyor can remove poor quality potatoes and place them in defective bins directly beside them. After the poor quality potatoes are removed, the line narrows until each potato is evenly spaced. The spacing could be achieved without the vertical spacers that are currently in place. Without the vertical spacers, the line can be remodeled to remove the approximately 2" gap between the first conveyor and the second removing the necessity of an operator at Station 3. We also recommend conducting a study to determine the root cause of the defective shrink wrapping. Many potatoes are shrink wrapped incorrectly and if the problem was identified and solved the efficiency of the process would dramatically increase.

Figure 3: Corrected Line

Calculated Impact

Quick Fix

Relieving the worker at Station 4 of some of her assigned tasks will result in a better overall quality of product being shipped out to the customer and less idle time at Station 1. The final results are contained below in Figure 4. Refer to Appendix C for the redone Line Balancing calculations. This quick fix would cost the employer nothing while simultaneously improving productivity and quality.

Station 1: Task 1 Time: 16.1 sec
Station 2: Task 2 Time: 41.8 sec
Station 3: Task 3 Time: 41.8 sec
Station 4: Task 4 Time: 38.0 sec

Figure 4: Redone Line Balancing

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Appendix C: Line Balancing Calculated Impact

Line Balancing (Corrected)

[1]

Time (sec)	Task
16.1	1
41.8	2
41.8	3
38	4

Task 1 ➡ Task 2 ➡ Task 3 ➡ Task 4

[2] Takt Time= (480 min per day) / (688 boxes per day) = 41.9 seconds

[3] Precedence Matrix

Task	Time (sec)	1	2	3	4
1	16.1		1	1	1
2	41.8			1	1
3	41.8				1
4	38				

[4] Positional Weight

Task	Sum of times	Positional Weight
1	16.1 + 41.8 + 41.8 + 12.3 = 137.7	1
2	41.8 + 41.8 + 38 = 133.9	2
3	41.8 + 38 = 92.1	3
4	38	4

[5] Number of Workstations = Sum of task times/ Takt time = 137.7/41.9 = 3.28

4 Workstations are needed

[6] Workstations:

Workstation 1: Task 1 Time: 16.1 sec
Workstation 2: Task 2 Time: 41.8 sec
Workstation 3: Task 3 Time: 41.8 sec

Figure 1: Sample Student Work from Community Partner #1

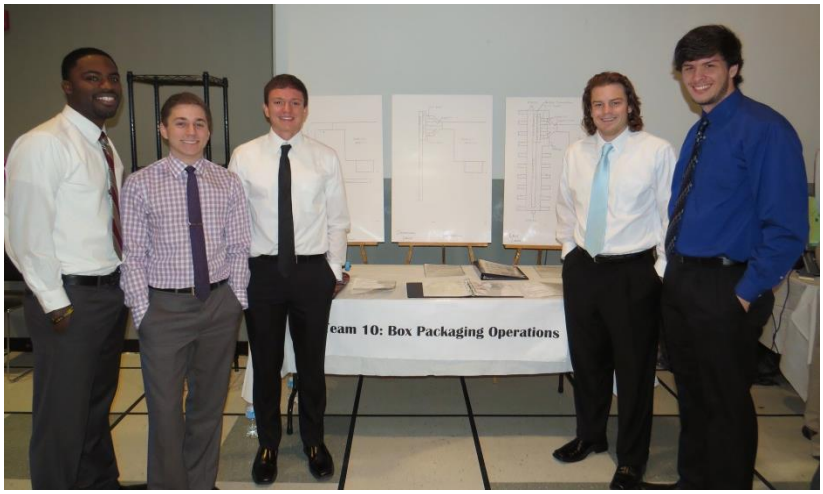
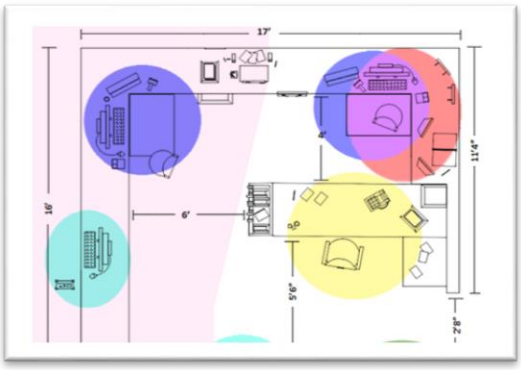


Figure 2: Project Showcase

Community Partners #2 and #3

During the second year of the course, we partnered with two community agencies during the same course: the Starkville Public Library and Starkville High School. Both agencies presented similar problems to the students: how to improve the flow of operations, as well as how to improve the ergonomics for the workers. At the library, student teams focused on the circulation desk and book re-shelving operations. At the high school, the focus was placed on the cafeteria.

Sample student work associated with the library (left) and cafeteria (right) are shown in Figure 3. Some of the benefits of working with the library and high school included easy accessibility, high availability of staff for interviews, ease of data collection, and easy to understand processes. Disadvantages included a lower complexity process, student privacy issues (at the high school), and perceived lack of importance of the partners' needs.



Area: A and B	Inches	Height/Depth Category*	% Used **
Serving Shelf	36.75	Elbow (stand)	5%
Tray Location	51.75	Forward Reach	5%
Hand Sanitizer	23.25	Elbow (stand)	5%
Chair Height (Max)	32	Popliteal	99%
Chair Height (Min)	32	Popliteal	1%
Screen (from table)	11.5	Elbow Fingertip	5%
Chair Height (Max)	30.125	Popliteal	99%
Chair Height (Min)	30.125	Popliteal	1%
Handle Height	37.75	Elbow (stand)	5%
Desk (from monitor 1)	17	Elbow Fingertip	5%
Desk (from monitor 2)	19.5	Elbow Fingertip	5%
Fridge Handle 1	30	Elbow (stand)	5%
Fridge Handle 2	48	Elbow (stand)	5%
Doorway (width)	36	Hip Breadth	99%

*Konz-Johnson Table **Female

Figure 3. Sample Student Work from Community Partner #2 and #3

Community Partner #4

The most recent community partner was the T.K. Martin Center for Technology and Disability, specifically their seating and mobility services. At the center, the staff work to assess the needs of a specific client, and then recommend a mobility device that can help them achieve improved functionality. Figure 4 shows the wheelchair room in which clients are able to try different sizes and models of wheelchairs. Students assessed the fitting process used both at the center as well as in client's homes.

Example student work is shown in Figure 5. Students explored the variety of steps involved in the mobility assessment process, and determined ways to improve the process in order to improve various outcomes. The advantages of working with the center included its proximity to campus, unique problem and needs, and engaging project mission. However, the staff had limited availability to assist the students, which caused some difficulties in project execution.

Figure 4. Wheelchair Fitting Equipment

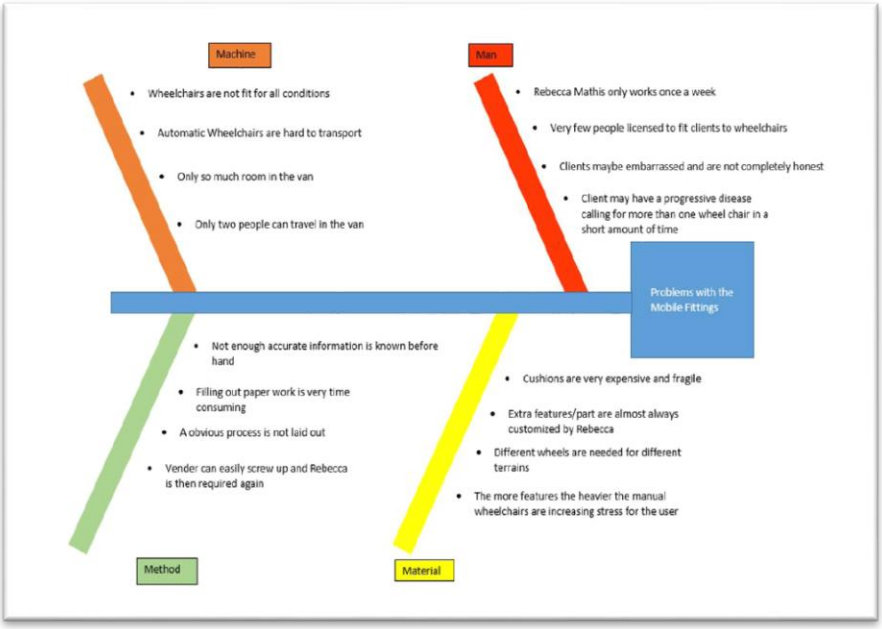


Figure 5. Sample Student Work from Community Partner #4

Student Feedback

At the end of each semester, students complete a survey about their service-learning experience. The survey included both Likert scaled and open-ended questions. The survey contained five sections: demographics, career and personal, community engagement, ergonomics and service-learning, and open-ended questions.

For the fall 2015 semester, 44 students participated in the survey, and 41 complete surveys were returned. Of the 41 participants, 73.17% (n=30) were male and 26.83% (n=11) were female. Regarding classification, 68.29% were junior standing (n=28) and 31.71% (n=13) were senior standing. Additional demographic descriptions are shown in Table 1.

Table 1. Summary of Demographic Variables

Demographic Variable	Category	N	%
Cumulative GPA	4.00	1	2.44%
	3.50-3.99	16	39.02%
	3.00-3.49	13	31.71%
	2.50-2.99	9	21.95%
	2.00-2.49	2	4.88%
	Below 2.00	0	0%
Parents attended college	Yes	36	87.80%
	No	5	12.20%
Parents graduated from engineering discipline	Yes	10	24.39%
	No	31	75.61%

Transfer Student	Yes	13	31.71%
	No	28	68.29%
Volunteer in community	Yes. Frequently	6	14.63%
	Yes, sometimes	20	48.78%
	Yes, rarely	13	31.71%
	No	2	4.88%

A summary of student survey responses for the three primary survey question categories (career/personal, community engagement, ergonomics & service-learning) are shown in Table 2. Overall, students agreed that the service-learning project was beneficial towards their training as an engineer, and that it helped to strengthen a variety of valuable skills. It also allowed students to understand how engineering could be applied to help with community needs. Finally, students agreed that the service-learning course allowed them to deepen their interest in and understanding of the course topics.

Recommendations for Service-Learning Implementation

The literature and the survey data, reported above, present evidence of the benefits of incorporating service-learning in the industrial engineering classroom. Given the experience of working with these four community partners over three course semesters, the following recommendations are given in order to improve the change of a successful service-learning course implementation:

- Encourage students early and often to invest their time, energy, and ideas into the project.
- Devote a small amount of time to the project in each class period and integrate its discussion into course topics.
- Do not put unnecessary constraints on student design recommendations. If the community partner has a constraint (e.g. limited finances), ask students to create one solution with those limited resources, and one with unlimited resources. This encourages creative thinking.
- Emphasize the importance of engineers providing service throughout the course, so that students begin to develop an altruistic view of their chosen profession.
- Choose a community partner with as much availability (time and location) as possible. Encourage clear and frequent communication between the partner and student teams.
- Train students in effective project management techniques. Depending on the course level, this may be the first larger scale course project for many students. Project management guidelines should include developing a scope, creating a reasonable timeline, and establishing team conduct guidelines.

Table 2. Summary of Likert-Scaled Survey Responses.

Career/Personal Questions		SA	A	N	D	SD
Q9	My Service-Learning project was beneficial to my training as an engineer.	21.95%	**43.90%**	29.27%	4.88%	0.00%
Q10	The service-learning project helped strengthen my teamwork skills.	24.39%	**56.10%**	17.07%	0.00%	2.44%
Q11	The service-learning project helped strengthen my analytical skills.	14.63%	**58.54%**	21.95%	4.88%	0.00%
Q12	The service-learning project helped strengthen my communication skills.	14.63%	**53.66%**	31.71%	0.00%	0.00%
Q13	The service-learning project helped strengthen my technical writing skills.	9.76%	**41.46%**	41.46%	7.32%	0.00%
Q14	My Service-learning team did not work well together.	7.32%	7.32%	21.95%	**34.15%**	29.27%
Community Engagement Questions		SA	A	N	D	SD
Q15	I developed a greater sense of personal responsibility to my community through my participation in this service-learning project.	17.07%	21.95%	**48.78%**	12.20%	0.00%
Q16	I feel closer to my community after working with the service-learning project.	2.44%	24.39%	**56.10%**	17.07%	0.00%
Q17	I have a greater interest in being more proactive in my community because of the service-learning project.	12.20%	19.51%	**56.10%**	12.20%	0.00%
Q18	The service-learning project showed me how engineering can be applied to help my community.	26.83%	**65.85%**	2.44%	4.88%	0.00%
Q19	I do not believe the service I was doing made a difference.	7.32%	17.07%	**34.15%**	31.71%	9.76%
Ergonomics & Service-Learning Questions						
Q20	I deepened my interest in the subject matter of this course.	4.88%	**65.85%**	19.51%	9.76%	0.00%
Q21	Working on the service-learning project helped me learn the course topics in Industrial Ergonomics.	7.32%	**56.10%**	17.07%	17.07%	2.44%
Q23	Completing the service-learning project allowed me to gain additional knowledge compared to a traditional (non-Service-Learning) course.	9.76%	**60.98%**	24.39%	4.88%	0.00%
Q24	I would not want to complete another service-learning project for a course.	4.88%	4.88%	**41.46%**	41.46%	7.32%
Q25	Students should complete a service-learning project before graduation.	14.63%	**48.78%**	34.15%	2.44%	0.00%

Notes: Bolded font indicates most common response; Q14, Q19, and Q24 are flipped scale questions. SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly Disagree

References

1. Corporation for National & Community Service (2013). College student volunteer rates. Retrieved from: http://www.volunteeringinamerica.gov/rankings/States/College-Student-Volunteer-Rates/2013
2. Jacoby, B. (2015). *Service-learning essentials*. San Francisco, CA: Jossey-Bass.
3. Heffernan, K. (2001). *Fundamentals of service-learning course construction*. Providence, RI: Campus Compact.

4. Kuh, G. (2008). High-impact educational practices: What they are, who has access to them, and why they matter. Association of American Colleges & Universities. Retrieved from: https://www.aacu.org/leap/hips
5. Cress, C., Collier, P., & Reitenauer, V. (2005). *Learning through serving*. Sterling, VA: Stylus.
6. Jacoby, B. A., & Associates (1996). *Service-learning in higher education: Concepts and practices.* San Francisco, CA: Jossey-Bass.
7. Astin, A. W., Vogelgesang, L. J., Ikeda, E. K., & Yee, J. A. (2000). *Executive summary: How service learning affects students.* [Electronic Version]. Retrieved from http://www.heri.ucla.edu/PDFs/rhowas.pdf
8. Claus, J. & Ogden, C. (1999). An empowering, transformative approach to service. In *Service learning for youth empowerment and social change* (pp. 69-93). New York: Peter Lang.
9. Rhoads, R., & Neururer, J. (1998). Alternative spring break: Learning through community service. *NASPA Journal*, *35*(2), 100-118.
10. Eyler, J., Giles, D., Stenson, C., & Gray, C. (2001). At a glance: What we know about the effects of service-learning on college student, faculty, institutions, and communities, 1993-2000: Third edition. Available at http://www.compact.org/wp-content/uploads/resources/downloads/aag.pdf
11. Eyler, J., & Giles, D. E. (1999). *Where's the learning in service-learning?* San Francisco, CA: Jossey-Bass.
12. Tsang, E. (2000). *Projects that matter: Concepts and models for service-learning in engineering*. Washington, DC: American Association for Higher Education.
13. Ritter-Smith, K., & Saltmarsh, J. (1998). *When community enters the equation: Enhancing science, mathematics, and engineering education through service-learning.* Providence, RI: Campus Compact.
14. Lima, M., & Oakes, W. (2014). *Service-learning: Engineering in your community*. New York, NY: Oxford University Press.
15. Sevier, C., Chyung, S., Callahan, J., & Schrader, C. (2012). What value does service learning have on introductory engineering students' motivation and ABET program outcomes? *Journal of STEM Education*, *13*(4), 55-70.
16. Duffy, H., C. Barry, et al. (2009). Service-learning in engineering science courses: Does it work? *Proceedings of the ASEE Annual Conference and Exposition*, Austin, TX.
17. Strawderman, L., Elmore, B., & Salehi, A. (2009). Exploring the Impact of First-Year Engineering Student Perceptions on Student Efficacy. *Proceedings of the American Society for Engineering Education (ASEE) Conference*.
18. Strawderman, L., & Ruff, L. (2011). Designing Introductory Industrial Engineering Courses to Improve Student Career Efficacy. *International Journal of Engineering Education*, 27(5), 1019-1026.
19. Strawderman, L. & Ruff, L. (2010). Improving Industrial Engineering Career Efficacy through Introductory Course Design. *Proceedings of the American Society for Engineering Education (ASEE) Conference*.
20. Bauer, D., Heier, J., & Strawderman, L. (2012). A Review of Capstone Course Designs Used in Industrial Engineering Programs. *Proceedings of the American Society for Engineering Education (ASEE) Conference*.

21. Cannon, A., Strawderman, L., & Heiselt, A. (2014). Service-Learning in the Industrial Engineering Classroom. *Proceedings of the 2014 Industrial and Systems Engineering Research Conference*, Montreal.
22. Cannon, A., Strawderman, L., & Heiselt, A. (2014). Connecting Students to the Community through Ergonomics Projects. *Proceedings of the HFES 2014 International Annual Meeting*, Chicago, IL.