Applications of Service Research within Industrial Engineering

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Abstract

Motivated by Mercer University's theme "Research that Reaches Out," the authors composed a 2015 ASEE-SE paper investigating how industrial engineers use their skills in "Service to Humankind." This follow on paper describes how the authors used this knowledge to pursue three service research related senior design projects for industrial engineering students.

Working with Macon Area Habitat for Humanity, a senior design team observed, analyzed and improved the process of deconstructing blighted properties. They designed and developed several improvements to the process and determined under the right conditions that deconstruction was a viable option compared to the more typical demolition approach.

A second team worked with the Macon Transit Authority to improve their bus routes inside the city. After observing the bus transportation process and analyzing data, the students developed a method to improve on-time performance by modifying the bus schedule to align with observed stop times.

A third team worked with an elementary school to reduce the throughput time and road congestion for their carpool process. The process was observed, data collected, and improvement ideas were simulated and presented to the school. A follow-on senior design project for implementing one or more improvement ideas is anticipated.

Keywords

Service Research, Humanitarian, Community Service, and Senior Design Projects.

Introduction and Background

In 2015, Mercer University was preparing for accreditation by the Southern Association of Colleges and Schools (SACS). SACS requires each accredited University to provide a Quality Enhancement Plan (QEP). Mercer University selected "Research that Reaches Out" as their QEP topic. This topic is derived from one of Mercer's five mission components, Service to Humankind:

> Service to humankind is ingrained in the Mercer culture. It is found in its academic units – a medical school dedicated entirely to preparing primary care physicians for rural and other medically underserved areas of Georgia and a law school widely recognized for its contributions in the arena of public service – to signature programs like Mercer On Mission that deploy students and faculty across the world to alleviate human suffering.

As industrial engineers, the authors' training and focus have been dominated with the notion of helping industry and government become more efficient and profitable. The idea of service to humankind was therefore somewhat new territory and resonated with the authors. As a result, Schultz and Dunbar[1] authored an ASEE-SE paper entitled "Review of Service Projects within Industrial Engineering." Their paper provided numerous examples of service research projects based on industrial engineering principles and techniques. These examples were organized into three areas: community service, the healthcare industry, and logistics. These examples can be found in references 2 through 11.

Uncovering these examples helped motivate the authors to identify and pursue three service research projects: the Macon Area Habitat for Humanity Deconstruction project, the Macon Transit Authority Bus Route Improvement project, and the Alexander II Elementary School Carpool Process Improvement project. All three of these projects were industrial engineering senior design projects.

This paper begins with a brief explanation of the course, Senior Design, in which these "service to humankind" industrial engineering projects were accomplished. The three projects are then presented starting with the team members, a background statement, a brief description of the work accomplished, and a statement of the results and conclusions.

Senior Design at Mercer University

Senior Design, at Mercer University, consists of self-formed teams of 3 to 4 students. These teams can be either single or multi-disciplinary. Senior Design is a two semester course. During the first semester, the team designs a solution to an engineering problem presented either by an external client or an internal faculty client. As deliverables, the students develop a formal Preliminary Design Review (PDR) and present their design to their faculty manager and client. The faculty manager and clients give the go-ahead to proceed into the next phase, or request revisions before proceeding.

In the second semester, the students build and test their designs, and modify as necessary. The students then develop Critical Design Review (CDR) report and again make a formal presentation to faculty, clients and interested students.

The Macon Area Habitat project was completed in the Fall 2015 and Spring 2016 semesters. The second two projects were completed in Fall 2016 and Spring 2017. These Senior design series consisted of 30 to 35 teams of approximately one hundred students.

Macon Area Habitat for Humanity Deconstruction Project[12]

Team – the project team consisted of four industrial engineering seniors, Johnathan Easter, David Murtaugh, Dan Pirovano and Ben Spears and their technical advisor Dr. Scott Schultz.

Background – the Macon Area Habitat for Humanity is a non-profit, charitable organization that focuses on community building in low-income areas. Their work is primarily focused on the construction of good quality but affordable housing. In Macon, Georgia, Habitat has used an

approach of concentrating these building efforts in a particularly blighted neighborhood call Lynmore Estates. So while their primary focus is construction, to improve the overall neighborhood, they have also worked on removal of blighted and abandoned properties.

Blighted properties, as shown in Figure 1, are typically removed through a demolition process of simply bulldozing the building and disposing of the materials in the local landfill. An alternative approach is called deconstruction. The idea of deconstruction is to reverse the construction process and remove the building materials and repurposing materials where possible, thereby reducing the amount of material placed in landfills.

Figure 1: Blighted property readied for deconstruction

Habitat was approached by several local churches to consider using the deconstruction approach to remove blighted properties in Lynmore Estates. The idea included using local personnel who had run into hard times and were in need of work. This project would be a win on many fronts including:

- resale of recovered materials by Habitats' Restore;
- removal of blighted properties to reduce crime, increase property values and improve the sense of community;
- hiring of local labor;
- and, reducing materials placed in the landfill.

Upon learning about this project, the authors approached Habitat with the idea of having a team of industrial engineering seniors observe the project, make recommendations on process improvements, and analyze the economic viability of deconstruction versus demolition.

Work Accomplished

The senior design team observed and collected data on the deconstruction of three properties in Lynmore Estates. The data collected included time studies, financial records, and general observations. During this time of observation, the students identified several process improvement actions that helped improve the efficiency and financial viability of the deconstruction process. These improvements included:

- using the volunteer labor force as much as possible;
- developing a measurement and cutting jig (see Figure 2) to expedite the de-nailing process, the bottleneck of deconstruction;

- providing cordless power tools to improve worker efficiency;
- and, identifying the types of properties that should be deconstructed versus those that should be demolished.

The financial analysis indicated that with the improvement actions identified above, deconstruction is financially viable, roughly on par with the demolition process. However, to remain financially viable, a steady stream of deconstruction projects must be available to maintain the deconstruction workforce.

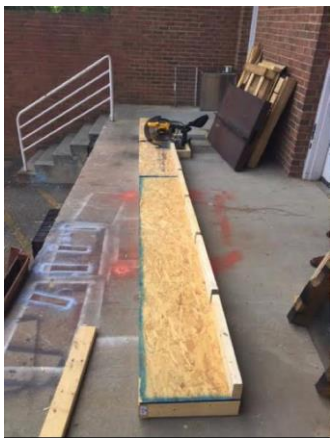

Figure 2: De-nailing jig

Results and Conclusions

The deconstruction senior design project was presented to Macon Area Habitat for Humanity with the conclusion that use of deconstruction in Lynmore Estates would proceed only on a limited basis for the time being due to the random nature of receiving blighted properties. Habitat would still deconstruct the most valuable reusable materials from properties being demolished.

This project also resulted in being recognized by Mercer University as one of 4 primary examples of how Mercer is engaging in the local and global communities to make a difference in peoples' lives. The Habitat Deconstruction article can be accessed at http://reachout.mercer.edu/georgia/. The cover page of this article is shown in Figure 3.

Figure 3: Mercer University article concerning "research that reaches out"

Macon Transit Authority Route Improvement Project[13]

Team – the project team consisted of two industrial engineering seniors, Trey Hartman and Dylan Hazelrig and their technical advisors, Dr. Pablo Biswas and Dr. Scott Schultz.

Background – the Macon Transit Authority, or MTA, is public-private company that provides bus service for the city of Macon-Bibb County, GA. MTA's mission statement is "As the recognized Public Transportation provider in Macon-Bibb Count, Georgia, we are committed to the provision of high quality, dependable and affordable service to the citizens and visitors of our community. Our efforts include support and encouragement to our City and County governments, our State and our Country in efforts to produce a stable and productive environment that fosters well-being and growth. We are dedicated to improving the image, usability and acceptance of our service to the entire population of our society. At the same time, we must remain a cost-conscious organization that provides a service that is recognized, welcomed and used as needed by all segments of our community." Figure 4 show an aerial view of current MTA bus routes.

The faculty advisors approached the MTA with the idea of reviewing their bus routes to see if industrial engineering tools such as scheduling and simulation could be used to make their routes more efficient and profitable. The initial idea was that routes could possibly be redesigned or combined to improve ridership.

Of significant importance is that while the authors were approaching MTA about an industrial engineering project, MTA was also working with a company that was installing a data collection system that records when buses arrive at designated stops and the number of customers that enter and leave the bus at each stop.

Figure 4: MTA bus routes

Work Accomplished – the team began this project with virtually no knowledge of bus systems. Therefore they approached this project as a "discovery" project with no concrete objective other than helping MTA improve their operations.

The team initially believed that changes to bus routes might improve operations. So while information was being collected about bus operations, tools were developed, such as simulation models, which could analyze alternative routes. However, as the project evolved, the students determined that the primary goals of MTA operations were bus reliability and on-time performance.

The students believed that reliability was primarily influenced by good preventative maintenance and replacement of aging equipment. This appeared to be outside the scope of a senior design project. Therefore they focused on the second object of on-time performance.

On-time performance is a measure of the difference between actual arrival time and the scheduled arrival time. With the installation of the new data collection system, there was a

wealth of new data which identified actual arrival times at bus stops. The students found that because the data collection system was in its infancy, much of the data had to be "cleaned." The students' primary efforts in the project therefore were making sure the data made sense, eliminating bad data, and using good data to determine realistic arrival times at bus stops.

Results and Conclusions – the students analyzed the 10 active bus routes used by MTA. Using data collected for over a six month period, the students produced new bus schedules which dramatically improve on-time performance, see Table 1 for an example. There would be virtually no cost to MTA to implement, they simply need to post these new bus schedules.

Table 1: Example changes to bus stop times

Terminal Station (AM)			Ponce De Leon (AM)		
Current	Late	New	Current	Late	New
5:40:00	0:06:51	5:46:00	5:50:00	0:01:26	5:51:00
6:20:00	0:05:37	6:25:00	6:30:00	0:02:42	6:32:00
7:00:00	0:02:37	7:02:00	7:10:00	0:05:50	7:15:00
7:50:00	0:08:29	7:58:00	8:00:00	0:05:51	8:05:00
8:40:01	0:02:29	8:42:00	8:50:01	0:00:28	8:50:00
9:30:00	0:08:13	9:38:00	9:40:00	0:03:25	9:43:00

While to our knowledge, MTA has not yet implemented new stop times, the quote from MTA's primary consultant after reading the students' report is:

> "Thank you so much for sharing this with us. Your students have given us excellent data to study, and I wholeheartedly support their suggestion that this project must be continued. Many people will benefit from this."

Alexander II Elementary School Carpool Process Improvement Project[14]

Team - the project team consisted of three industrial engineering seniors, Jacob Edwards, Matthew Harris, and Catherine Raybould and their technical advisors Dr. Pablo Biswas and Dr. Scott Schultz.

Background – The PTA president and principal of the Alexander II Elementary school approached the authors concerning the desire to improve their carpool process. Construction of a round-about on the edge of their property had required Alexander II parents to use an alternative approach to dropping off and picking up their children, see Figure 6. It currently takes about 30 minutes for the carpool process to complete each afternoon. Worse yet is that parents start lining up 45 to 60 minutes prior to pickup which causes traffic congestion on the city streets and leads to irate drivers.

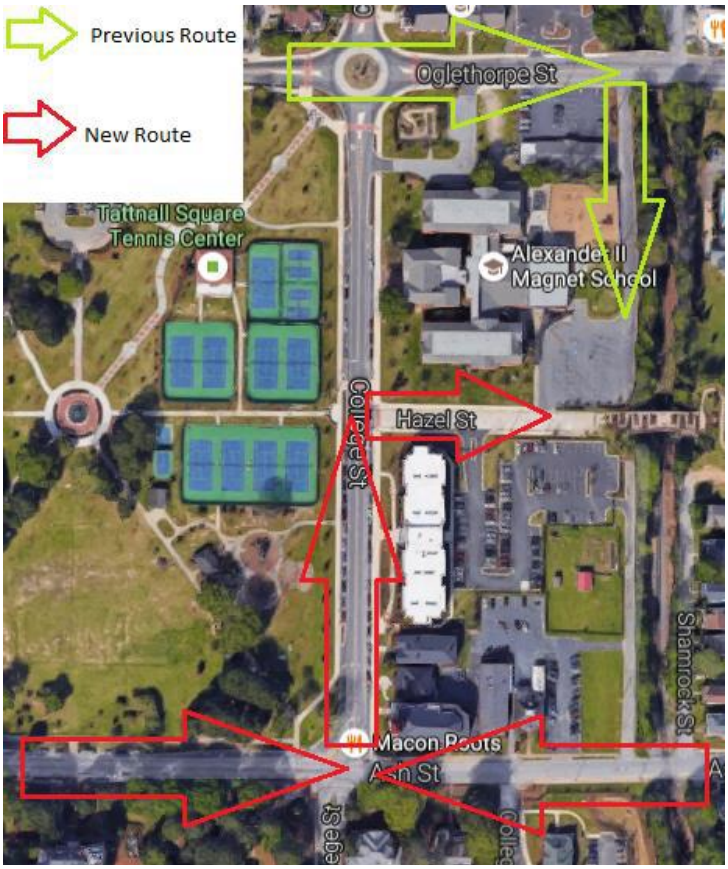

Figure 6: Previous and new carpool lanes

The PTA president and school principal requested that a study be performed to identify ways to relieve the traffic congestion and improve the throughput time of the pickup process.

Work Accomplished – the student team spent several days collecting data and observing the process. They then developed several improvement ideas including:

- have grades released to different areas around Tattnall Square park;
- have families with 3 or more students pick up in the school van area;
- connect College Place to Ash Street by constructing a back road;
- have two lanes of traffic down Hazel Street to begin the process;
- service 5 cars simultaneously in the pickup area; and,
- develop a phone app to notify method of pickup.

Finally, the team developed a simulation model to test how combinations of these improvement ideas impact the throughput time and reduction in congestion, see Table 2

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Table 2: Simulation improvement times for throughput and congestion

Rank	Solutions	Simulated Cars off College St. Time	Current Cars Off College St Time	% Improvement	Simulated Carpool Completion Time	Current Carpool Completion Time	% Improvement
1	Change Service Lot Size + Van Area + 2 Lanes Down College Pl.	3.35 PM	3.43 PM	35%	3.42 PM	3.49 PM	24%
2	Change Service Lot Size + Van Area + Backroad	3.36 PM	3.43 PM	30%	3.41 PM	3.49 PM	28%
3	Change Service Lot Size + Van Area	3.38 PM	3.43 PM	22%	3.42 PM	3.49 PM	24%
4	Change Service Lot Size + 2 Lanes Down College Pl.	3.40 PM	3.43 PM	13%	3.46 PM	3.49 PM	10%
5	Change Service Lot Size + Backroad	3.41 PM	3.43 PM	9%	3:46 PM	3.49 PM	10%
6	Change Service Lot Size + Different Grades to Different Areas (Walking)	3.27 PM	3.43 PM	70%	3.31 PM	3.49 PM	62%
7	Change Service Lot Size + Different Grades to Different Areas (Bus Ride)	3.29 PM	3.43 PM	61%	3.35 PM	3.49 PM	48%

Results and Conclusions

The students presented their findings at a PTA meeting and in a second meeting with the principal. Some of the improvement ideas were impractical and others required a significant capital investment. However, the principal was particularly interested in the phone app for notifying the school of the method of pickup and the 5 car lot-size recommendation. The principal that the team worked with is currently being promoted and has handed off the report to the incoming principal for consideration of which ideas to implement. A future senior design team will be tasked with developing the phone app.

Summary

The authors were motivated by Mercer University's "Research that Reaches Out" quality enhancement plan that emphasizes "Service to Humankind." The authors thus intentionally looked for industrial engineering senior design projects that provided service to those in the local community that are typically underserved. Three such projects were undertaken by design teams from 2015 through 2017, a Habitat for Humanity deconstruction project; a Macon Transit Authority route improvement project; and the Alexander II elementary school carpool process improvement project. Not only did the local organizations obtain benefit from these studies and improvement actions, but the students and faculty obtained a greater appreciation for what these service organizations provide to their communities.

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