AC 2010-2420: A SERVICE LEARNING CASE STUDY: AN EFFICIENCY STUDY OF A METROPOLITAN BUS TRANSIT SYSTEM

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A SERVICE LEARNING PROJECT: AN EFFICIENCY STUDY OF A METROPOLITAN BUS TRANSIT SYSTEM

Abstract

This paper describes a multidisciplinary, collaborative service learning project. The focus of the project was an efficiency study of a public transportation system located in a mid-sized city. A team comprised of faculty and students from the Political Science, Engineering, English, and Computer Science Departments was assembled to develop and conduct the study. The study team recommended several short term efficiencies that could be easily and quickly implemented. The study team also proposed a massive realignment of the current transportation system. The proposed new transportation network system is based on a multi-hub approach and cross docking principles.

This project was an excellent illustration of how industrial engineering draws upon a variety of different disciplines, from mathematics to psychology, from communications to political science, from sociology to computer science. It provided students from varied disciplines an opportunity to collaborate and work toward a common goal; the improvement of the municipal bus transportation system. Furthermore, because the passengers were the essential components in the transportation system, students experienced industrial engineering as a "people-focused" discipline, not simply a hard science focused on technology, methods and machinery.

Introduction

Evansville is a mid size city of approximately 114,000[1] people located in southern Indiana. The Metropolitan Evansville Transit System (METS) was created in 1971 to provide public transportation throughout the city. Currently, METS is based on a traditional single-hub and spoke arrangement. All routes originate at a main terminal (hub), travel a predefined route and return to the main terminal. METS operates thirteen fixed routes, from 5:45 a.m. to 12:15 a.m., Monday through Friday. METS also provides limited service on Saturday, and does not operate on Sunday or national holidays.[2]

Recent changes in the city's demographics, an increase in the Hispanic population and movement of people to outlaying areas prompted the Mayor's office to ascertain if METS was still meeting the needs of their constituents. In a period of declining tax revenue and increasing gas and operating expenses, the municipal government was feeling the strain of economic conditions.

In the early spring of 2008, the University of Southern Indiana's (USI) Center for Applied Research was approached by the mayor's office to complete an efficiency study of METS. A research team comprised of faculty members from the Political Science, Engineering, English and Computing and Information

Sciences Departments was assembled to design and implement the METS study. Since no financial support was available, the study was formulated as a service learning project, which utilized upper level and graduate students to assist with the data collection and analysis effort.

Service learning has been defined as "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development."[3] Service learning projects have shown to be an effective means of engaging students and allowing them to develop professional and interpersonal skills.[4] Therefore, several institutes of higher education are exploring ways to incorporate service learning projects into an engineering curriculum.

Purdue University founded the Engineering Projects in Community Service (EPICS) program in 1995. EPICS is an academic program in which teams of students partner with local not-for-profit organizations to provide technology solutions to existing problems. Participation in EPICS is voluntary. Students can join a team during the second semester of their freshman year and remain with the team until graduation. The duration of projects varies with complexity and may require several years to complete.[5] The program has been nationally recognized and received several honors including awards from the Carnegie Foundation, the National Science Foundation and the American Society for Engineering Education.[6]

Columbia University has been successfully using service learning projects as part of an introductory engineering course since 2004. However, unlike the EPICS program, participation in this course is mandatory for all engineering students. Students form teams and are assigned a community service project. Throughout the semester teams are responsible for providing weekly progress reports and at the end of the semester teams propose a final solution to the initial engineering design problem. Implementation of service learning as part of the freshman design course has been well received by students and faculty at Columbia. Also, empirical evidence indicates that since the implementation of community service learning projects into the engineering design course curriculum, the freshman retention rate has increased. The successes achieved at Purdue and Columbia suggest that community service projects are the perfect venue for simultaneously introducing students to engineering principles and real world professional experiences.[7]

This paper describes a collaborative research study that was conducted as a service learning project by faculty and students at USI. It begins with a description of the study approach. This is followed by an overview of a conceptual transportation network that was developed by a team of engineering students. The paper concludes with a discussion of the educational value of this project, conclusions and future work.

Approach

The METS efficiency study consisted of several components, including: (1) an analysis of current communication and marketing efforts, (2) a rider satisfaction survey and collection ridership utilization data, and empirical observations, (3) a community survey, (4) interviews with community service organizations, and (5) a route/transportation analysis. To support this undertaking, teams of students from the Political Science, Engineering, English, and Computer Science Departments were assembled. Faculty members managed each team and provided advice, guidance and direction throughout the study process.

Students enrolled in an Intercultural Technical Writing class studied the current communication and marketing efforts. The primary focus was on the METS web site, transportation guides and route signage. Students researched current literature on communication techniques and preferences specific to the Hispanic culture. Based on this research, the students made five key recommendations to improve the public transportation system. First, develop a bilingual rider guide with Spanish side-by-side with English and in the same font. Second, standard international symbols for police, hospital, post office, shopping, parks, etc. should be utilized. Third, use numbers and letters to name routes. Currently routes have English names such as Washington or Walnut, which can be confusing for multicultural users. Fourth, fabricate removable magnetic signs depicting the bus route and place the route maps inside the bus or affix it to the outside of the bus. The fifth and final recommendation was to include the name/number of each route on bus stop signage, such that individual bus routes and major transfer points are easily identifiable.

To supplement the marketing and communication effort, a team of computer science students developed a web based route selection application as a senior design project. This concept involved building a website that utilizes the Google mapping utility to allow individuals to "plan" their trip on METS. Potential riders simply input their starting point and destination. The application determines the bus route and provides a map with a textual description, including transfer points and fare information, of the recommended route. A prototype model has been developed and is currently undergoing testing and debugging.

The rider satisfaction survey was written and administered by upper level students enrolled in a political science research methodology course. This same group of students collected ridership utilization data and recorded empirical observations (such as safety, cleanliness, route inconsistencies and customer service issues) regarding the overall bus system. In addition to collecting survey data, the students rode the buses for a period of four weeks to collect utilization data for each of the current routes. During this four week timeframe, students recorded the time, and number of passengers boarding and exiting the bus at each stop on a route.

The community survey was prepared by graduate students in the Master of Public Administration (MPA) program. The intent of this survey was to collect information from people that did not currently use the bus system and try to pinpoint services or system features that might entice new users. The survey was administered in person by MPA students at local establishments such as grocery stores and shopping centers. In addition, this survey was implemented online through the USI Office of Institutional Research.

Faculty members from the research team also met with various community service organizations. The purpose of these meeting was to address shortcomings with the current system and assuage concerns regarding potential route modifications and efficiency recommendations. Since approximately 75% of the current METS users were at or below the poverty line, it was critical that routes providing service to locations such as local food banks, shelters, social service offices, schools, and medical facilities were not eliminated. Furthermore, there was a need for services to some locations (such as the detention center) that was currently not provided by METs and should be considered when planning future bus routes.

A team of upper level engineering students enrolled in a Transportation and Logistics class were assigned the task of analyzing the efficiency of the existing METS transportation network. For the purposes of this study, efficiency was defined as "providing the necessary services to community members at the lowest possible overall costs." It was assumed that costs could be reduced by focusing on two primary objectives; minimizing total mileage traveled and maximizing ridership. Minimizing the total distance (mileage) traveled would reduce operating, maintenance and fuel costs. Whereas, maximizing ridership would lead to more customers and increased revenues. Higher revenues and lower operating expenses would result in a more efficient transportation system.

To support their analysis, the students assembled information from a variety of sources. Quantitative data was derived from historical records provided by the METS office and from actual ridership data collected by the political science student teams. The engineering students also considered the subjective data collected from the rider satisfaction survey, community survey, and interviews with community service organizations. Finally, the students participated in several meetings with METS officials to discuss current resources, constraints and relevant public policies. Google Earth[8] was used to generate a map of the current transportation system shown in Figure 1. The small bus icons represent major transfer points and the colored lines represent the routes followed by the METS buses.

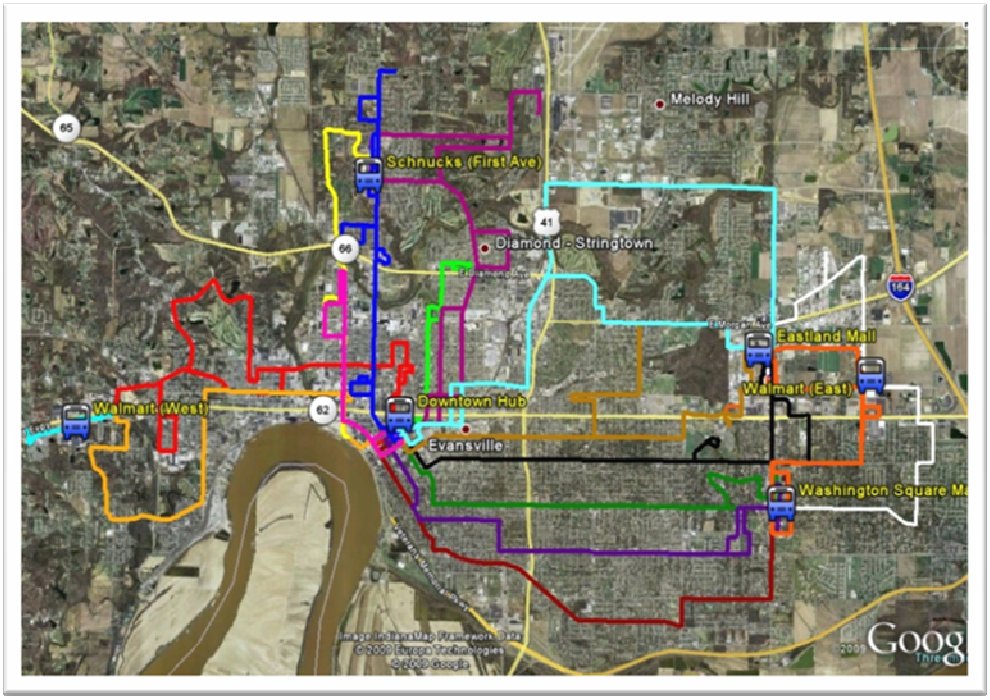

Figure 1. Current METS routes.

Proposed Transportation Network

Although the study team identified many short term efficiencies that could be easily and quickly implemented, the engineering student team concluded that significant, long-term improvements could be realized through a major overhaul of the current system. The students suggested a multi-hub transportation network that incorporated cross docking principles. A high level, conceptual design of the proposed "transportation network" is illustrated in Figure 2.

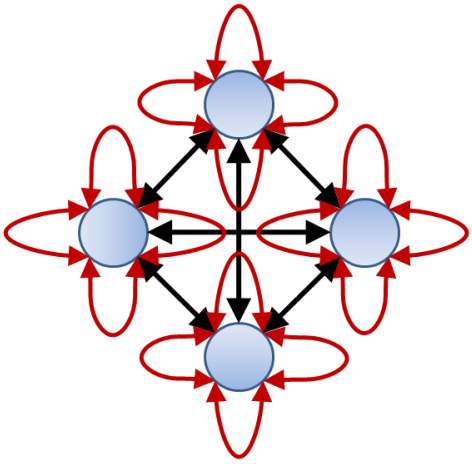

Figure 2. Multi-hub based transportation network.

Under this approach the city is divided into four areas. Each area would have a hub (designated as a circle) and a fleet of buses to cover the different routes in the area. To facilitate cross-town transportation, there would be direct connections between these hubs. Ideally, this system would be synchronized and support overlapping routes to minimize customer travel time. Furthermore, this design facilitates expansion as the city continues to grow.

A map of the proposed transportation network that is based on a multi-hub approach is shown in Figure 3. Notice that the tentative locations of the four hubs are designated with small bus icons while the routes followed by the METS buses are designated with colored lines.

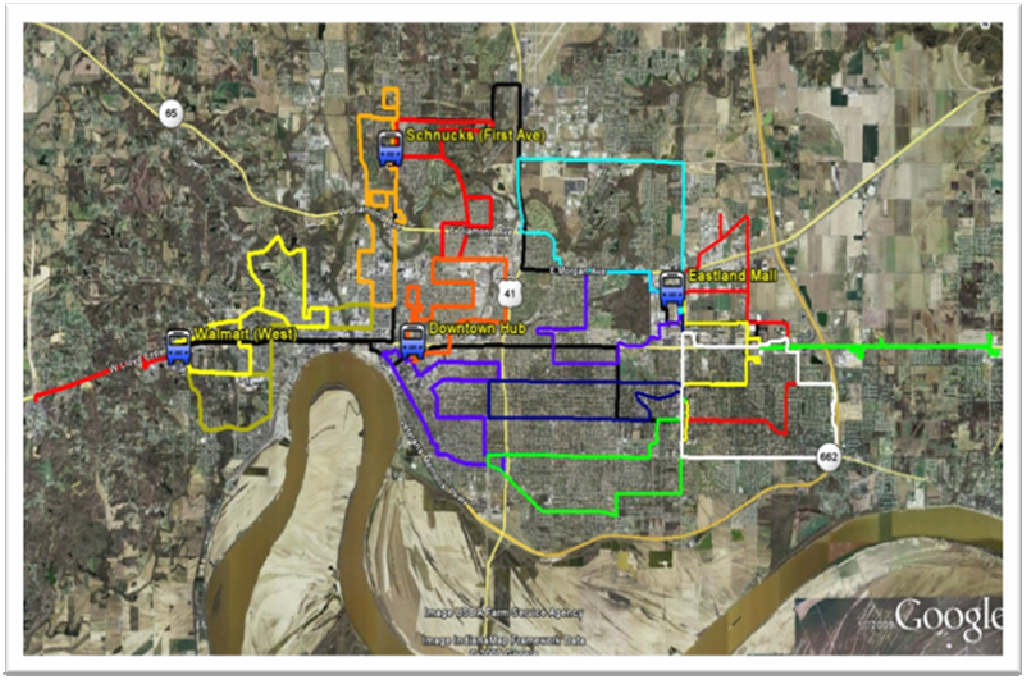

Figure 3. Multi-hub Based Transportation Network.

The majority of the proposed transportation network design incorporated input provided by METS officials with respect to several aspects, for instance the tentative number and location of hubs, number of routes in the system, area to be covered, etc. Ridership utilization and input from community service organizations was also considered during the design of the proposed transportation system.

The proposed multi-hub transportation network is a new way to look at bus routing and when implemented will yield numerous efficiencies.[9] However, determining the optimal hub locations and development of specific routes will require additional rider utilization data and input from METS officials. Furthermore, this effort is not without its challenges. Different types of transportation resources may be needed to implement the changes. Also, implementation of the proposed transportation network is challenging as METS

may have to simultaneously operate under the current approach in some sectors of the city and under the new approach in others. Depending on the level of commitment, it may take five to ten years to fully implement the proposed public transportation network.

Educational Value

The METS efficiency study provided an opportunity for students from varied disciplines to collaborate and work toward a common goal; the improvement of the municipal bus transportation system. Participating in this service project allowed students to become more cognizant of public policy issues and community impact. Upon completion of the study, students reflected on the process and the multitude of problem solving skills utilized throughout the study.

Several students stated that they were proud of the fact that they were helping solve some of the city's problems and it was rewarding to work on a project that may actually be realized. Engineering students gained valuable experience working with an actual transportation network and have a deeper appreciation for the complexities underlying a logistical/transportation system. Also, since the engineering student team based a great deal of their analysis on data provided by outside sources, they developed an appreciation for the value of thorough and consistent documentation. This was evidenced in the records and information they prepared for future student teams that may become involved with follow-on METS projects.

This project also allowed students to experience and gain a broader understanding of the concepts of strategic, tactical and operational planning and decision making. The multi-hub transportation network represents a major paradigm shift and will require a minimum of five years to be fully implemented. Participating in the development of this transportation network exposed students to strategic planning issues and problems inherent to long-term decision making. For example, when selecting a hub location, students had to consider projected population growth, downtown revitalization efforts, and new housing construction. Students also developed recommendations to improve the current transportation system. These recommendations could easily be implemented over the next two years and provided excellent examples of tactical planning issues, such as notifying the public of route changes, and updating signs and relocating benches along bus routes. Finally, the data collection effort exposed students to the daily operational issues frequently encountered by METS officials. Typical operational issues included unexpected road closures, employee illnesses and vehicle breakdowns.

The research team faced several challenges, including resource constraints, changes in METS leadership, the lack of a complete system map, and a migrating website. However, none of these difficulties were insurmountable. Students devised innovative ways to deal with resource constraints. For example, the

engineering student's maximized their use of free software, such as Google Earth[8] to develop maps and study the geography of Evansville and the computer science students used Google Maps[10] as the platform for their web based route selection application.

Overall, this project was an excellent illustration of how industrial engineering draws upon a variety of different disciplines, from mathematics to psychology, from communications to political science, from sociology to computer science. All of the student teams were actively involved in some aspect of the design of an efficient large-scale integrated system of people, equipment, and information. Furthermore, because the passengers were the essential components in the transportation system, students experienced industrial engineering as a "people-focused" discipline, not simply a hard science focused on technology, methods and machinery.

Study Conclusions

The study results suggested five basic strategies to improve the economic efficiency of METS. First, METS could raise rates. However, since three-quarters of current METS riders have incomes below the poverty line, this would be an unpopular option. Second, METS could reduce services. This may also be an unpopular strategy, especially when users are asking for expanded route coverage and services. Third, METS should consider working with the county and/or private businesses to develop a cost-sharing program that would allow the bus service to be expanded to industrial areas located outside the city limits. While this idea has merit, it was determined to be outside the scope of the current project. Fourth, METS could initiate a campaign to attract more riders. More riders would bring in more funding from fares. Finally, METS could work towards developing a new transportation network similar to that depicted in Figure 3.

After reviewing the study results, the Mayor's office and METS officials were interested in pursuing development of the proposed transportation network. They believed that an efficient reliable transportation system would be the first step in attracting new riders. Also, an efficient route system would improve vehicle utilization. However, development and implementation of this network will require resources, including an intensive additional data collection effort.

Future Work

Future plans are to develop a simulation model of the Evansville public transportation system. Once the model is tested and deemed valid, it will be used as a decision making tool to assist with determining the optimal hub locations, route modifications, bus stop locations and evaluate timetables. However, at this point, there is insufficient ridership data to develop a mathematically valid simulation model. Development of this model will require a significant data

collection effort to gather additional ridership data, along with information regarding area populations, employment locations, and current and forecasted demographics trends. The USI Center for Applied Research is currently discussing follow-on opportunities with METS and considering different options to support this data collection effort.

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