# Integrating Design in Construction Service-Learning

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This article describes service-learning activities associated with community service jointly performed by two academic programs, Construction Management (CM) and Civil Engineering Technology (CET), of the same department. Emphasis is presented on describing those tasks developed by the project team. This service work was to assist the town of Vidette, GA, in designing its new water distribution system (WDS). The characteristics and size of the project and associated service-learning tasks required the engagement of both programs, CM and CET, during several semesters. Almost forty students, five faculty members, two licensed industry professionals, and one public officer participated in this still ongoing project. Once approved, the resulting design documents (drawings and specifications) would be employed by the town to apply for loans or other forms of needed financial assistance to build its new WDS. To assure the attainment of required minimum standards, the department obtained the pro-bono participation of a professional engineer, a registered land surveyor, and guidance from the approving state agency. The service-learning activities resulted in the collection of all needed topographic data, preparation of design documents, cost estimates, and scheduling of construction tasks.

**Key Words**: service-learning, community service, integrated project, water distribution system

## Introduction

In the last half century, service-learning activities have been increasingly encouraged by the US government and by institutions of higher education in the USA. In 1969, service-learning pioneers attended a now often cited conference in Atlanta, GA. It was sponsored, among others, by the Southern Regional Education Board (SREB) and proposed the following recommendations (SREB, 1970):

- Colleges and universities [should] encourage student community service, assist in assuring disciplined learning as part of this service, and award academic recognition for the learning acquired by students in service projects.
- Federal, regional, and state and local governments, colleges and universities, and private organizations [should] provide opportunities and supply the funds required for as many students as are needed and are willing to engage in service activities.
- Students, public and private agency officials, college faculty and staff [should] cooperate in the administration of programs in which students both serve and learn.

In 1985, the presidents of Brown, Georgetown, and Stanford Universities and the president of the Education Commission of the States formed Campus Compact, a national coalition to promote service-learning, civic engagement, and community service in higher education. Today, more than 1,100 college and university presidents participate in it. Campus Compact "provides resources and training for faculty seeking to integrate civic and community-based learning into the curriculum" (Campus Compact, 2010).

In 1993 the US government created the Corporation for National and Community Service (CNCS). This federal agency is the nation's largest provider of grants supporting service and volunteerism (CNCS, 2010). One of its programs, Learn and Serve America, supports innovative service-learning programs performed by institutions of higher education.

In 2005, the Carnegie Foundation for the Advancement of Teaching released a revised version of its former single classification system of educational institutions. The new version consists in a set of multiple, parallel classifications that allowed to view US colleges and universities through different lenses. In December of 2006, the Carnegie Foundation awarded its first elective Community Engagement classification to 76 colleges. A recent study (Driscoll, 2008) on this application of the new classification concluded that: "The national recognition accompanying the new classification thus has enhanced both the prominence and promise of community engagement in higher education." In December 2008, 119 new colleges were awarded the Community Engagement classification. However, Amy Driscoll, who oversaw the selection process, expressed concern on the fact that only a few applying institutions indicated having promotion and tenure policies recognizing and rewarding scholarship associated with community engagement. In this regard, she indicated: "there is still work to be done" (Schmidt, 2008).

Proven benefits associated to service-learning are numerous (US House of Representatives, 2009). Some of them apply to students, some to faculty members and some to the community they serve. Many academic institutions present a list of them in their Internet pages (University of Minnesota, 2010) (Leeward Community College, 2010). Examples of those benefits are: promotes students' active and hands-on learning; promotes critical thinking and problem-solving abilities; demonstrates to students the use of learned theories in practical applications; builds self-confidence; improves interpersonal skills, especially in the areas of communication, collaboration, and leadership; develops civic responsibilities; leads to new avenues of research and publication; increases faculty opportunities for recognition and rewards; builds partnerships with the local community; generates community awareness of college programs and services; provides needed community service.

Currently, the authors' institution is in alignment with the national tendency of incorporating, or further developing, service-learning in higher education. It joined the Campus Compact coalition in fall 2008. Similarly, since 2007, the authors' academic unit strongly promotes and recognizes the benefits resulting from the participation of students and faculty members in service-learning projects such as the work described in this article. In particular, the herein reported project presented numerous challenges and required several semesters to complete it. Work started in October 2007 and the final stages of completion were being attained at the time that this article was reviewed (i.e., December 2009).

## Problem Statement

The problem addressed in this service-learning project was the kind very familiar to many small towns throughout the country. Often, they face design and construction challenges related to roadways, rain-water drainage and erosion control systems, water distribution and treatment facilities, utilities, etc. In this case, a small Georgia town had experienced serious problems with its 100-year-old water distribution system and did not have the resources needed to design a new system suitable for construction. This situation prompted the mayor of Vidette to seek assistance from an institution of higher education to design a new WDS for his town during summer 2007.

*Request for Assistance to Generate Design – Service Opportunity*

The authors became aware of the town's predicament following receipt of a letter, dated July 27, 2007, from the mayor, which clearly stated the call for some assistance: "Vidette is in need of replacing our century old water distribution system. The town is unable to afford the price charged by private engineering firms." Unfortunately, the town had a highly deteriorated, obsolete water system and no funds or any form of financial assistance to cover the costs associated with the design of a new system. If the design were to be performed, the town could use it to apply for loans and/or seek other financial resources to cover the estimated construction costs of the new system. Since Vidette is a small town with approximately 30-32 houses, the CMCET Department concluded that assistance could be provided as community service; engaging undergraduate students and faculty members from both programs (CM and CET) via service-learning activities. Also, in order to assure a quality final product, industry professionals would be invited to participate on a pro-bono basis. Fortunately, a professional engineer from Thomas & Hutton Engineering Co., Chris Stovall, and a registered land surveyor, Robert "Tate" Horton, generously accepted to join and assist our student-faculty teams.

## Water Distribution System for the City of Vidette, GA

*Brief Descriptions of the Old and Future Water Distribution Systems*

In 2007, the old WDS of Vidette served approximately 110 inhabitants. The system did not have water meters or fire protection. The system consisted of a metallic, 900-gallon, cylindrical tank located on the ground, in an elevated area of the town. Actually, the tank was located in the middle of the intersection of two streets. The water was pumped to this tank from a well that was situated about 10 feet from the tank. The well was 275-300 feet deep and consisted of a 6-inch diameter pipe that went through two different rock layers to reach good quality water. The maximum pumping rate was 50 gallons-per-minute. Since the capacity of the tank was small, the pump started every 15 minutes. The distribution piping consisted of 1-1/4-inch galvanized pipes, with some black-roll and PVC. All distribution lines were dead-end type (no looped lines) and there only were a few cutoff valves in the system. Because of this, it was often necessary to cutoff water to the entire town to fix a leak. The number of leaks was progressively increasing; prompting the need to completely replace the existing old system with a modern one.

Considering the slow population growth of the town, the team decided to design the new system to serve twice the number of current inhabitants. The system would include a new hydro-pneumatic tank. All new distribution lines would have a looped design with valves located to ensure that future leak repairs would minimize/eliminate service interruption for residents of the town. All users would have water meters and the system would be able to support fire protection. For this protection, the town expected to acquire and attach hydrants to the main lines in the future. An on-ground reservoir would be used to support the fire protection needs of the town.

*Partnering from the Start*

In August of 2007, the authors made arrangements to bring together the main professional partners of the project. Also, the university attorney was invited to the meeting to ensure that the interests of all parties were clear. A formal agreement was not prepared, but an understanding was reached that a survey would be performed and a design would be prepared and given to the mayor of the town. The meeting was attended by the mayor, the authors, a CET faculty member, the area Environmental Protection Agency representative, and the campus attorney.

*Design of the New Water System - Required Data and Resulting Products*

In order to design the new system, it was necessary to produce a topographic plan of the town. This plan needed to present the horizontal location and elevation of enough points to obtain a good three-dimensional approximation of the ground surface at, or near, the locations of all new pipes and a water tank. The plan should also show the location of all current residences and commercial buildings. It was clear that this was a considerable task. It would cover an area of approximately 60-80 acres. Once collected, the topographic data would be entered into specialized computer programs (such as EPANET or WaterCAD) to design the new water system (including the proper selection of sizes and locations of the tank, pipes, valves, meters, future hydrants, etc.). The final products consist of drawings and specifications. These final documents must be approved by the corresponding state agency, the Georgia Environmental Protection Agency.

*Division of Work*

Given the size and characteristics of the project, the CMCET Department decided on an integrated approach that would bring together students and faculty from its two programs, CM and CET.

In addition to the authors, two faculty members from the CET Program were also engaged in the project. To assure the quality of the final products would meet professional design standards, it was considered necessary to incorporate the pro-bono services of a licensed land surveyor, a professional engineer, and the area representative of the Georgia Environmental Protection Agency (EPA).

The following list summarizes the main tasks involved in the project:

(1) Obtain design parameters and regulations from the corresponding water authorities.
(2) Collection of all topographic data and development of corresponding plan.

(3) Estimation of the design water demand and selection of type and size of tank.
(4) Design of piping distribution network using computer software, EPANET and/or WaterCAD.
(5) Development of final drawings and specifications.

Task (1) was performed by CM faculty members assisted by the professional engineer and the representative of the Georgia EPD. Task (2) was mainly performed by sophomore and junior CM students and CM faculty members. It was assisted by the land surveyor. Tasks (3)-(5) were assigned to senior CET students and CET faculty members. These tasks were supervised by the professional engineer.

*Scope Creep*

As the project progressed, it became clear that additional value could be provided by the CM students that were involved. Several students were charged with the additional task, which included:

(6) Cost estimation and scheduling of construction tasks.
(7) Obtain permitting information/materials.
(8) Identify funding sources that could support the construction of the new system

Tasks (6) and (7) were performed by a senior CM Honors Program student under the guidance of one of the authors. Task (8) is still underway and is being conducted by a senior CM Program student.

## Service-Learning Tasks Developed by CM and CET Students, Professors and Industry Professionals

*Collection of Topographic Data by CM and CET team members*

The data collection tasks were performed in three stages: (I) The first phase consisted in the materialization of twelve vertices of a closed traverse (vertices A-L) in Vidette. It was performed by the authors, the surveyor and one volunteer CM sophomore student, T. Ryan Rowland, during a weekend. The corresponding data processing was completed by one of the authors during the same weekend. This phase resulted in the relative horizontal location of all twelve points of the closed traverse. This established traverse was used as reference for the subsequent stages. (II) During the second stage, relative elevations of all traverse vertices were determined. This differential leveling task was performed by several volunteer students and the authors. (III) The final stage of the data collection was the longest one, lasting several weekends. This stage was performed by students and was supervised by one of the authors. Also, the professional surveyor proved to be a valuable member of the team during this task. The task itself consisted in the collection of X-Y-Z coordinates of numerous selected points on and near the streets of Vidette.

To complete all three stages, the CM participants employed modern, reflectorless Topcon total stations (model GPT-3007W, Pulse). These instruments are the laser-based type used in regular plane surveying courses offered by the CMCET Department. They possess single-axis compensation, laser plummets, a single display, and present an angular precision of 7 seconds. Therefore, they are considered construction-grade instruments (not survey-grade instruments). However, they allowed our team to obtain accurate measurements and work within required tolerances. For example, the traverse calculations showed that the angular error of closure was 78” in 1800º. This represents an angular correction of almost – 6.5” per angle (compared to the 7” of angular precision of the instrument). The lineal error of closure was 0.269 ft (or 3 ¼ inches) in 6,659 ft. This corresponds to a linear precision of 1 in 24,711. The enclosed area of the traverse is 34.4 acres.

Data collecting devices were not available to us at the time of this work. Consequently, the data was recorded by students and professors in field books by hand. However, the licensed surveyor contributed to the third stage by collecting data with a powerful robotic total station and its accompanying electronic data collector. As a consequence, participating students had the opportunity to observe the efficiency of this powerful and more costly instrument.

During regular surveying classes, participating students had already learned the use of electronic distance measuring (EDM) devices, the measurement of angles in direct and reverse mode, and had practiced traverse calculations. Therefore, student T. Ryan Rowland already had the appropriate knowledge when he volunteered to participate in stage (I). Similarly, the students who volunteered their participation in stage (II), including T. Ryan Rowland again, already had practiced differential leveling in class. This was not new to them. However, in both stages, students were performing these tasks for the first time in a real-world situation and not as a class exercise. It was clear that, students who participated more than once developed a sense of ownership of the project and were willing to assume more responsibilities. Often, they asked to be designated and perform as party chiefs.

The third stage, which involved several students, is where service-learning occurred. The students received instructions in the field and learned in an “on-the-job-training” fashion to successfully complete this phase of the work.

As indicated above, the third stage of data collection consisted in the direct acquisition of spatial coordinates (North-East-Elevation) of numerous points along the streets, gutters and sidewalks of Vidette, using total station instruments. This particular topic had not been covered in our plane surveying courses. Mainly, this lack of coverage was due to the fact that total station instruments were first available to our students in the fall term of 2006 and old procedures were progressively being replaced by the new ones. Since the direct collection of 3D coordinates by total stations is a powerful and widely used approach to generate topographic plans or to calculate earthwork (cuts and fills) on construction sites, it was decided to incorporate it into our courses during the fall term of 2007. For this purpose, a new field problem was designed and assigned to the students. It presents all step-by-step instructions to properly use the available total stations to collect 3D coordinate data.

Between September and December of 2007, more than thirty students and five faculty members participated in the three stages of topographic data collection, which included nine visits to the town of Vidette. Seven of those occurred during weekends. Students were given the option of learning these topics in our regular surveying classes on campus or skipping them and learning the topics in the field on the Vidette water distribution system project.

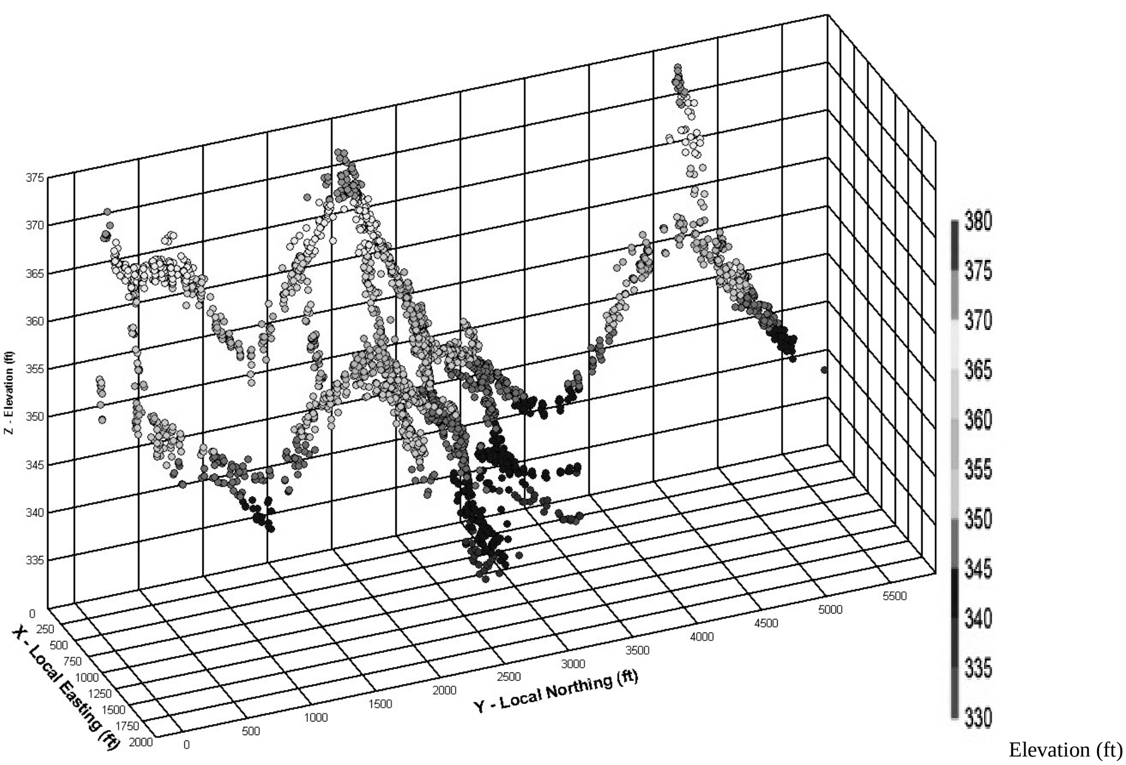


*Figure 1*: Partial sample of 3D data collected along the streets of Vidette, GA (the vertical scale is exaggerated.)

Always, students worked in groups of 2 to 4 members.  Each group has a designated party chief and was in charge of a total station instrument.  Each party had flexibility to choose the points they considered appropriate for the generation of the required topographic plan.

As a result of this activity, the coordinates of approximately 2200 points (6600 numbers) were collected by students and professors.  Then, the points were manually entered into a Microsoft Excel spreadsheet.  After processing and reducing them into the state plane coordinate system (SPCS), they were sent to CET students who exported them to AutoCAD for drawing purposes.  A three dimensional visualization of part of the collected data is presented in figure 1.

Judging by the number of participating students, it can be inferred that the proposed topographic service-learning activities for the town of Vidette were positively received by students.  Thirty (30) students selected to join their professors during weekends or other days and learn while performing community service.  Several of them participated on more than just one occasion.  In particular, student T. Ryan Rowland participated in stages (I), (II), and in all but one event of stage (III).

While performing these activities, the authors noticed that students showed signs of increased motivation.  Most likely, this was due to the fact that, after receiving necessary instructions, students recognized their levels of assigned responsibilities:  (a) each group received and controlled their own assigned instruments; (b) some students were asked to perform as party chiefs; and (c ) all students were allowed to use their own criteria to select the points where topographic data was to be collected.

A rapport was developed between all participants, students and professors.  It was apparent that teaching and learning was performed in an atmosphere more conducive to the acquisition of knowledge.  Competition also developed among groups.  Teams were anxious to collect the largest amount of data in a given day.  Always, by close of business, they were immediately asking if their group was the "winner" of the day.  For this, some groups extended their coordinate data collection as far in the evening as natural daylight allowed them.

Evaluation and quality control of the collected data was performed by participating faculty members and industry professionals.  The continuity of the collected data allowed for verifications.  This was the main indicator of the quality of the work performed by students.  During data collection, a few mistakes were made and corrective action was needed.  However, no substantial time was lost.  For example, a group used a wrong initial azimuth and all their collected data was rotated with respect to the referenced North direction.  This was corrected by performing a mathematical rotation of all collected points by that group with the help of an electronic spreadsheet.

### *Design service-learning tasks by CET team members*

During the spring term of 2008, a group of four senior CET students took the Senior Project course taught by a CET faculty member, and initiated the design tasks and drawings for the Water Distribution System of Vidette.  In that opportunity, the professional engineer, and one of the authors helped guide these students to initiate the design phase and produce the first drafts of required drawings.

During summer 2008 a new group of four senior CET students, took the Senior Project course taught by another CET faculty member.  They continued the work initiated by the previous group and made substantial progress in the design of this system.  They produced plans that were submitted to the engineer who thoroughly reviewed them and sent required revisions back to the students.  During the fall semester of 2008, these same CET students guided by the same CET faculty member, made those corrections and sent the revised drawings, and a set of specifications, to the engineer.  After the plans and specifications are approved by the engineer, they will be submitted to the Georgia EPA where they will be considered for approval.  By completing this project to the satisfaction of the professional engineer, students are showing their acquired new abilities.  Currently, the engineer is working in the final stages of this project.

*Additional service-learning tasks by CM students*

During fall 2008 and spring 2009, a senior CM student developed his Honors Project under the supervision of one of the authors. To assist with the preparation of his assigned project, the student was able to contact and gain support from an experienced construction company. His Honors Project consisted in the following main tasks:

1. Communicate with (and acquire information) from all participants of the WDS project (students, professors, professionals, the mayor of the town, and personnel of the approving agency).
2. Seek and obtain assistance from an experienced construction company.
3. Perform and document a quantity and cost estimate of the WDS project.
4. Perform and document a schedule of the preconstruction and construction activities of the WDS project.
5. Obtain documentation for needed construction permits and inform the mayor accordingly.
6. Produce a complete final document following the requirements of the University Honors Program.
7. Present the Honors project at the annual Honors Symposium sponsored by Georgia Southern University.

The student performed the above tasks and helped the mayor of Vidette set up a Georgia Utility Permitting System account. His cost estimating work suggested a potential total bid price in excess of $600,000.

Since the town of Vidette will not be charged for this design project, it is estimated that this may save the town approximately $25,000.

During the current semester, fall 2009, additional student team members, from the CM program, were assigned the following ongoing tasks:

1. Communicate and coordinate with students, professors, and professionals associated with the design documents of the new WDS of Vidette.
2. Communicate with the mayor of Vidette, to identify the financial needs of the town to build the new WDS.
3. Perform and exhaustive search of all federal, state and private financial opportunities (grants, loans, etc.) that may exist to fully or partially finance the new WDS of Vidette.
4. Prepare and submit a report documenting all possible financial opportunities including their specific requirements and perform a preliminary analysis of which funding opportunities could be pursued by the town of Vidette.
5. Make a presentation of all findings to the mayor and faculty members involved in this project.

## Closing Remarks and Lessons Learned

- In order to assist a small town in rural GA, an academic unit, the CMCET Department of Georgia Southern University, engaged its two programs (CM and CET) to design the new WDS for that town. The project was developed as a series of service-learning activities encompassing several semesters.

- To assure the quality of the final products, the Department sought and obtained the pro-bono participation and assistance of professionals in the engineering and land surveying fields. Also, the department contacted and sought the support of personnel from the approving state agency, the Georgia Environmental Protection Agency.

- The execution of all components of this service project was possible due to the employment of an integrated approach involving both, the CM and the CET programs.

- The project was subdivided into tasks which were assigned to different groups of volunteer students according to their respective backgrounds and academic needs. CM students concentrated in the collection of topographic data whereas CET students focused on the design of the WDS itself. Two CM faculty members guided the CM students and two CET professors supervised the activities assigned to CET students.

- A total of thirty-seven (37) students participated in this project. Twenty-four (24) of them were from the CM program and thirteen (13) were CET students. The collection of topographic data involved twenty-two CM students and eight CET students. Three of those eight CET students were later joined by another five (5) CET students to design the WDS as their Senior Project. One (1) CM student based his Honors project on the new WDS. He performed a quantity and cost estimate of the project and proposed a schedule of construction tasks. He also informed the mayor on the required permitting process. Other CM students are currently identifying funding sources that could be used by the town to finance the project.

- All participating students performed service-learning activities, i.e. during these activities students learned and demonstrated knowledge that they were required to obtain in courses they were attending. Their efforts also contributed towards the completion of a worthy community service project.

- Thirty (30) students selected to join their professors, during weekends or other days, to learn the use and work with modern, laser-based surveying instruments. Since students participated on a voluntary basis and several of them did it in more than one occasion, as it was the case during the collection of topographic data, it is clear that the service-learning activities were well received by them. They were not reluctant to participate. On the contrary, several showed excitement and motivation to learn the use and application of modern laser-based surveying instruments in a real project.

- It is worth mentioning that one CM student, T. Ryan Rowland, was involved in all stages (I, II and III) of the data collection. He participated in seven of the nine times teams visited the town. This particular student was a resident of the town being served.

- The data collected by surveying CM and CET students was of good quality. Only a couple of mistakes were made in the initial setup (orientation) of two stations. Fortunately, these cases were easily corrected by appropriate numerical data rotations and did not require the repetition of work.

- Students also learned various aspects of working with community leaders. Students and faculty were the frequent beneficiaries of small town hospitality as the mayor provided hearty meals to volunteers. The students also gained an understanding of the value that they can bring to clients.

- Participating faculty members were recognized by the time and efforts dedicated to this service project. One of them was nominated for the university award on excellence in service.

- It is estimated that this work saved the town approximately $25,000.

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