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Impacts of a University-wide Service Learning Program on a Senior Undergraduate Capstone Course

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Kelly Ellenburg serves as the Director of the Office of Service-Learning and the Smart Communities Initiative at the University of Tennessee, Knoxville. As the founder of the University's first Office of Service-Learning, Mrs. Ellenburg oversees a wide range of institutional efforts related to service-learning and serves as an entry point for community involvement in the same. She is also the founding director of UT's Smart Communities Initiative (SCI), a large-scale interdisciplinary service-learning collaborative that works with local government partners across the state to address a range of livability and resilience issues. The SCI is part of a growing network of Sustainable City Year Programs, the first of which was established at the University of Oregon. The program is designed to help communities advance long-term community development goals by leveraging university scholarship and community collaboration towards sustainable, equitable, research-based planning solutions. In 2014 UT adopted the SCI as the feature program for their new Quality Enhancement Plan (QEP), Experience Learning. The Office of Service-Learning is now preparing for expansion as the QEP moves into implementation. Mrs. Ellenburg is also the founder and chair of the University's Service-Learning Steering Committee, composed of designated faculty from each academic college working to build the profile and capacity of service-learning across campus through initiatives such as the "S" course designation and showcasing of best practices. Mrs. Ellenburg's work on campus-level initiatives at UT has included service on the 2015 SACS Quality Enhancement Plan writing team, the 2014 Carnegie Community Engagement writing team, the 2010 UT Community Engagement Task Force writing team, and coordinating author for the 2010 whitepaper "Student Ownership, and the College Experience." Last year she received the Chancellor's Award for Environmental Leadership for her leadership of sustainability-focused service-learning and the SCI. Mrs. Ellenburg serves on the Board of Directors for the Educational Partnerships for Innovation in Communities Network (EPIC-N), the Board of Advisors for East Tennessee Quality Growth, and as the University's designee and ex-officio Commissioner to the Governor's Commission on Volunteerism and Service. She holds a Master's degree in Higher Education Administration and a Bachelors of Fine Arts, both from the University of Tennessee, Knoxville. Mrs. Ellenburg is also a wife and mother of two girls, ages twelve and five.

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Abstract

Experiential learning in a civil engineering senior design project, or capstone, course requires significant preparation and coordination, but has been recognized as an extremely powerful pedagogy. The value of service-based learning in engineering education has been well documented as serving to better demonstrate "real world problems", improve community awareness and responsibility, and develop "soft skills" necessary for engineering practice. A university-wide service learning program provides an opportunity for enrichment of experiential learning within the Civil and Environmental Engineering (CEE) department at the University of Tennessee, Knoxville (UT). The relationship established through the university network provides opportunities that are not easily replicated through engineering-only experiential learning opportunities. The UT Smart Communities Initiative (UT SCI) program serves as a model for service-based learning as the interdisciplinary program strives to engage students from across the university to share in identifying solutions to address community needs. This program pairs university faculty and students with community partners, providing well-organized, dedicated teams able to develop solutions to complex multidisciplinary problems. The specific structure of this program, modeled after the University of Oregon Sustainable Cities Initiative, enhances the success of the student performance by suitably developing a partnership for which all entities involved are responsible and engaged, recognizing the need to maintain efficient communication and response to student needs with respect to the academic calendar. The following paper contains: a brief history of service-learning programs in engineering academia, a summary of the development and design of the UT SCI program, a summary of the UT CEE senior design project partnership during the inaugural year of the program, and recommendations for assessment of the program objectives with respect to the university, department, and community partners.

Introduction

Development of an experiential learning experience for capstone coursework provides engineering students a critical experience in their development towards professional engineering practice. Within a capstone, or senior design project course, well-designed service learning opportunities are highly applicable as the overarching objectives of such a service project, such as developing a cohesive report and performing applicable engineering computations, often directly aligns with the student learning objectives for the academic exercise. Recognizing the need to balance technical engineering expertise with "soft skills" associated with teamwork and engineer-client relationships, engineering undergraduate curriculum benefits from the experiential learning process; yet very few programs promote extensive experiential learning

opportunities integrated directly into the engineering curriculum. While indirectly referenced via student outcome criteria, the Accreditation Board for Engineering and Technology, Inc. (ABET) learning criteria for engineering programs support the intended outcomes of experiential learning without specifically requiring service learning activities in undergraduate curriculum. Focus on multi-disciplinary team experience, formulation and solution of engineering problems, and effective communication[1] all comprise the easily achieved outcomes from service learning opportunities.

While a single engineering department is capable of developing an experiential learning opportunity for undergraduate students, the development of a robust service-learning program can be hindered by a lack of resources and inability to provide truly interdisciplinary projects for students. Faculty support, continued program maintenance, and overall program management requires resources not always available at a department or college level. A formal service-based or experiential learning program can be developed within an engineering department, either as a function of the senior design course, or as integrated within the entire department, but historically, these isolated programs are short-lived and often replaced by individual faculty initiatives.

The development of a university-wide service learning program has numerous benefits across campus. Specific to the discipline of civil engineering, the development of such an extensive inter-disciplinary program promotes the simultaneous development of technical and professional skills. The Smart Communities Initiative (SCI) program at the University of Tennessee, Knoxville (UTK) has provided an extensive system for development of engineering senior design course projects. The opportunity provides coursework options that promote multi-disciplinary projects that combine teams of students across numerous disciplines or opportunities for civil engineering projects independently. Both opportunities promote development of design decisions and effective communication skills, and the university-wide framework improves the coordination efforts to enhance these learning objectives.

The following content includes a brief history of engineering service-based programs across the country, discusses the development and design of this specific university-wide service learning program, summarizes the CEE senior design project partnership during the inaugural year of the program, and provides recommendations for the assessment of the program with respect to the partnership between the university, the CEE department, and community partners.

Historic Engineering-based Experiential Learning Programs

Well-cited studies over the past 40 years promote experiential learning as opportunities that positively impact student learning through engagement[2,3]. While categorization can take many forms, the following discussion highlights three traits considered significant to the development

of a robust experiential learning program: university-wide reach, a financially-viable structure, and deliberate inclusion in the undergraduate curriculum.

Interestingly, multiple experiential learning programs founded in engineering colleges have demonstrated longevity and a few notable programs have prospered for upwards of half a century. Well-established programs such as those at the University of Cincinnati and the Harvey Mudd College represent on-going programs whose origins have now extended from engineering-only to university-wide programs focused on service learning[4,5]. These programs now are capable of promoting interdisciplinary projects and benefit students through experience beyond that of a specific engineering-partnered project. While extremely diverse, these programs are also formally incorporated into the curriculum of the engineering department. Students at both universities are required to participate in the program as a necessary path towards graduation.

Other programs continue to support work at a departmental level, leveraging relationships with alumni and developing a network specific to the discipline which provides a means for financial support. Worcester Polytechnic Institute's PLAN program engages the students within the college of engineering into a "Projects Program" which requires participation in various interactive and major projects prior to graduation[6]. University of Massachusetts ESIC program continues to thrive and has developed into a source of revenue for the Mechanical Engineering department[7]. Corporate sponsors for service projects are asked to contribute a nominal, tax-deductible fee to support the program. Efforts for NSF funding have also been successful for the Massachusetts' program as faculty have engaged with other colleagues within the university to enhance the opportunities for education of students within interdisciplinary fields. Case Western Reserve University is another example of extensive engagement and focus on developing experiential learning for undergraduate students. A thriving cooperative opportunity (co-op) program arranges three summer co-ops for all students in the engineering curriculum. Students are often provided the opportunity for a co-op experience and the work contributes to the required curriculum for graduation[8]. This co-op structure is common amongst engineering colleges across the country. Financial gains either through direct client contracts, academic funding outlets, or student employment opportunities are positive attributes for a successful service learning enterprise.

While various programs have experienced growth, some programs have diverged over time and are no longer deliberately described as experiential learning opportunities. West Virginia University's PRIDE program has been discontinued, yet the opportunity for experiential learning still exists as described in a recent capstone course syllabus[9] as well as numerous journal articles discussing the program's education methods and observations[10,11]. Similarly, Kansas State University's Mechanical Engineering Design Laboratory still exists as a required component within the undergraduate curriculum, but is not necessarily a deliberate service learning experience at this time[12]. These programs demonstrate the common reality for most civil engineering capstone courses, for which faculty solicit projects from volunteers in the local community, but the intention of instruction and learning is completely removed from the

experiential learning opportunity and replaced with a more controlled and sometimes 'closed-form' solution approach to the coursework. A recommendation to develop a university-wide service learning program that integrates the network of engineering professionals and is capable of developing a contractual relationship with community partners is provided in lieu of the status quo with the intention of providing a learning opportunity engaging students beyond academic circumstance.

Smart Communities Initiative (SCI) Framework at the University of Tennessee

The success of a robust service-learning program benefits from leveraging the resources of the university while significantly engaging the faculty at the department level. The development of university-wide service-learning programs is not unique. One of the most highly publicized programs is the Sustainable City Year Program hosted by Oregon State University (Oregon model). This specific program is a significant example as a demonstration of the potential pairing of university-wide interdisciplinary project solicitation with a financially-feasible and financially-favorable relationship between the university, community partner, and the faculty.

While many traits of the Oregon program are extremely effective, a distinct area of differentiation between the University of Oregon's Sustainable City Year Program and the University of Tennessee's Smart Communities Initiative (UT SCI) program is the operational "home" of the program. The Oregon model, like many programs of its type, is positioned within the academic college of the program's faculty directors. The UT SCI program however, is housed within the University's central Service-Learning office. This enhances opportunities and eases management of projects for most faculty participants. Coursework is partnered with proposed projects through this main contractual system, and projects requiring cross-discipline work are managed outside of a faculty department. Project leads work closely with faculty program participants to negotiate alignment between community needs and course learning outcomes, and to facilitate project needs.

While the nature and content of the project set changes from year to year, the need for CEE project work tends to be consistent across partners. Most UT SCI partners, by the nature of their mission or service to the community, request city planning-level work or infrastructure improvement needs, easily adapted to the civil engineering capstone coursework. The university-wide framework provided through the UT SCI program provides a means for consistent management and development of projects suitable for civil engineering design coursework. Engagement can be performed for all design-based undergraduate and graduate coursework in the CEE program, an extreme value for professors seeking project-based activities in a variety of courses.

Department of Civil & Environmental Engineering Inclusion

One specific value to the Department of Civil & Environmental Engineering at the University of Tennessee (UT CEE) through the SCI program is the enrichment provided to the senior design course curriculum, inclusive of both qualitative and quantitative student learning outcomes. As a result of the UT SCI partnership, seniors are provided projects with well-defined scopes of work at the beginning of the semester, opportunities to engage with civic and public officials, and occasional exposure to disciplines across the campus. In the inaugural year of the program, the UT CEE department partnered with the UT SCI program to complete a total of five projects. Students worked primarily in teams of only civil engineering students, with opportunities for teams to partner with Landscape Architecture and Architecture students. Ultimately, the SCI partner was provided a comprehensive report summarizing the efforts of all projects. Quality of student work, networking opportunities, and professional development engagement are all enhanced through the program. Though no quantitative measures have been collected, feedback from department faculty indicates a noted improvement in the rigor of student performance.

The CEE department has formulated small teams of students working on independent engineering projects to meet the needs of the community partner. Rather than a competitive design approach for which students might be sub-divided in order to provide multiple solutions to the same design need, teams of students work on independent projects to allow a greater impact on the community partner. All student work requires some component of alternative analysis, specifically incorporated into the project contract, such that the students are exposed to an iterative design process and to provide an opportunity for students to engage in suitable design-thinking activities. This approach is not universal across the program, as some graphic design and literature courses have promoted a competition in their courses to improve the diversity in the proposed solutions to community needs. The framework for this program permits development of course structure that meets the needs of both faculty and community partners. Often, for civil infrastructure projects proposed, it's been observed that the needs for optimal design can be achieved through a brief alternative analysis within a course-long project. Observations for our CEE school have also indicated greater ownership for independent work as opposed to some extensive sharing of solutions when students performed design in a competition setting, especially when the ultimate goal was a single design solution rather than an array of solutions. Student groups of approximately 4-8 students have been successful in identifying design alternatives and a 'best solution', with groups larger than this often struggling to ensure that each individual finds a suitable role and performs an adequate amount of engineering work throughout the entire term. While there are merits to different approaches of classroom team assignments, project alternative design approaches, and variations in team sizes, the university-wide program appears to be best served on a case-by case basis, for which the needs of the community are reflected in the team formulation in the academic course.

The university-wide program improves the management of the partnerships as the program structures the coursework and project development. Often, projects crossing disciplines retain

separate course numbers such that students in the civil engineering program can be assessed according to departmental standards. Project contracts are written prior to the semester to aid in formulation of expectations for all academic and community partners. Student learning objectives are directly incorporated into the contract to ensure that student assessment can be performed in accordance with the needs of the academic program. These contracts are shared with the students for all courses to clarify the diverse expectations for the differing disciplines; this further improves student understanding of collaboration across disciplines within traditional engineering projects.

Additionally, in the inaugural year, two approaches to project management occurred: one for which multi-disciplinary teams worked simultaneously on a project and one with staggered coursework. Staggered coursework allowed civil engineering students to develop preliminary design concepts for which architecture students could use to inform related design work, and paired work promoted collaboration by landscape architecture students and engineering students working on infrastructure with necessary input from both aspects of design in unison. Ultimately, success for both approaches is project and faculty specific, with both promoting the ability to measure student learning objectives specific to the appropriate profession while also satisfying the community partner.

As a result of the program organization, the university-wide program has enhanced student learning in the ABET focus areas of multi-disciplinary team experience, formulation and solution of engineering problems, and effective communication. Naturally, the students are driven to develop suitable solutions to the engineering needs presented by the service-learning projects and students engage actively with community project leads to communicate ideas and design concepts throughout the semester. Effective technical and non-technical communication is practiced and rehearsed with project partners and students improve through the iterations of presentations and project meetings attended. Additionally, multi-disciplinary team experiences are achieved through either civil engineering only projects, for which *disciplines* are considered as the specialization areas within the broader civil engineering discipline, and also partnerships outside of the department. Landscape Architecture and Architecture have partnered with the civil engineering disciplines for multiple projects. Ultimately, while most of these ABET focus areas are achieved through any project-based formulation, the university-wide program provides a framework that improves coordination efforts to provide the necessary opportunities for learning engagement with minimized efforts for the individual faculty member. At this time, most of the perceived enhancement is only through faculty observation, but the intended assessment protocol presented herein aims at measuring this improvement.

To further ensure the longevity of the service learning initiative as a formal requirement in the curriculum for the UT CEE department, the senior design course has committed to a permanent engagement with the SCI program. This commitment ensures that a majority of graduating undergraduate senior students participate in the UT SCI program. Currently, as a means of evaluation, a small number of CEE senior design students engage in alternative experiential

learning projects. Over the next years, assessment of program outcomes and student learning objectives will be measured to evaluate the inclusion in the SCI program. All current research indicates that the university-led program will provide more consistent resources and managerial support leading to a more sustainable program framework for the UT CEE department. Once this is confirmed, curricular changes will be recommended to formally integrate service-learning obligations as a component of the graduation requirements from the program.

Proposed Assessment of Partnership Objectives

Although the pedagogical value is clearly demonstrated for a service-learning based academic experience such as the UT SCI program, the effectiveness is not well justified without a well-designed assessment protocol. Ideally, the recommended assessment protocol identified within this report will be used to support current faculty observations through more quantitative measures. Considering the metric of Bloom's taxonomy, experiential learning can provide opportunities for all three domains of learning; namely: cognitive, affective, and psychomotor[13,14]. Well-designed service learning projects for civil engineering coursework incorporate the technical skills associated with demonstrating cognitive learning, engage the students in a social experience with exposure to community needs thereby promoting affective learning traits, and may even promote psychomotor development through site-civil work such as surveying, site sampling and testing, and construction activities. Assessment of the UT SCI program can encompass numerous aspects, including such components as student learning outcomes, university expectations, partner objectives, and overall success of the program to suit the needs and expectations of all stakeholders. Three major stakeholders exist in this particular partnership: the University (inclusive of course faculty, departmental curriculum committees, and administrative university leadership), the community Partner, and the engineering Student. To ultimately measure the value of the UT SCI program, overall partnership needs must align and agree.

The proposed assessment protocol recommends the compilation of results acquired from three major efforts:

- Interpretation of pre-project, mid-project and post-project surveys completed by all three stakeholder groups.
- Assessment of achievement of student learning objectives in service-learning courses.
- Evaluation of the financial impact derived from the service provided by the service-learning exercise.

A robust evaluation of the success of the project is developed through the analysis of the data obtained from these three major components of assessment. Though still under development, design of surveys will address individual perspectives on the expectations for the experience, understanding of the definition of a successful project, and content discussing the logistical ease

of the partnership. Broadly, the proposed surveys are intended to focus on perceived value by the students, community partners, and academic support staff. Questions designed for the surveys are intended only to measure the expectations to ensure that the project selection, development, and delivery meet the diverse needs of the entire team. Individuals will be surveyed independently and as groups three times through the project: prior to start of the project, at a mid-point in the design process, and at the conclusion of the semester. Results from the various groups will be compared to those partners working on senior design projects outside of the university-based program in an attempt to identify the value of this program compared to other project-based learning opportunities. Ideally, the university-based program will see areas of greater success in relation to development of student communication skills, successful management, positive student experiences, and achievement in project goals. Further research is necessary to identify the appropriate strategies for measuring these objectives and identifying the true benefits of the university-wide program in comparison to other project-based learning opportunities.

In addition to the surveys, student learning objectives will be evaluated through grading assessments to quantify the pedagogical success of the program. These results should be directly comparable as measurements of the value of one program over another; however, ultimately both university-wide and course-only programs are expected to be shown successful as all coursework has been designed with the intention of meeting student learning objectives. Potential results might signify an advantage of the university-wide program, which is ideal, yet measurement might only recognize an achievement of learning has been accomplished. For these circumstances, more detailed learning objectives might be identified as appropriate measures for the improvement in engagement in this specific project-based learning activity.

The third component of the assessment protocol proposed is unique in its endeavor to attempt to quantify the financial impact of the program and, in doing so, evaluate the sustainability of the program. The protocol recommends measurement of the following estimations: cost-savings provided for the Partner, financial incentive to the University, “value added” to the University, and equivalent training hours for the students. Ideally, an estimation of these three financial values will not only quantify the program’s financial impact, likely being a predictor of longevity and prosperity of the program, but will also provide a metric for overall performance of the program with respect to each stakeholder in the program. The representation of this financial metric will not be intended to promote the program as a tool for profit, but should demonstrate that the program is self-sustaining. Further, the financial value to the Partner and Student will not represent ‘true dollars’, as the work does not replace all necessary investments required for actual completion of a project. The measure of the financial impact will simply provide a measure relatable to ‘real world’ dollars, again, as a tool for assessment of the successful outcomes observed by each member of the partnership.

Concluding Remarks

The development of the UT SCI program as a university-wide service learning initiative at the University of Tennessee, Knoxville has provided an extensive inter-disciplinary learning opportunity valuable to the senior undergraduate curriculum in the Civil & Environmental Engineering department. While the partnership has enhanced the student performance and engagement in senior design coursework, the true measure of the success of this partnership resides in a thorough assessment program. The use of a series of surveys, integrated with a well-defined assessment of student performance, and development of a financial impact report is recommended to quantify the success of the program, but more importantly, ensure the longevity of the experiential learning opportunity. Integration of service learning is identified as highly impactful to the senior design coursework for the engineering program, quantifiable through the proposed assessment protocol. Further, the logistical structure of the university-level service learning program is assessed through this protocol and the entire structure and assessment routine is recommended to identify the overall success of such an endeavor.

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