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Development of Multicourse Undergraduate Learning Communities (MULC) in a Civil Engineering Technology and Construction Management Curriculum

Dr. Thomas Nicholas II, University of North Carolina, Charlotte
Dr. Don Chen, University of North Carolina, Charlotte

MULC: Multicourse Undergraduate Learning Communities

Abstract

The project based classroom has grown in popularity with the academic community, primarily due to the new generation of students responding poorly to the deductive, or professor centered classroom. Unfortunately, collaborative work or team assignments are frequently completed by students working independently during the project and combining work near the due date. This negates the intention of cross team communication and the group approach to solving problems. Regrettably, this model of team assignments where students work independently without the intended cross team communication is prevalent on many campuses nationwide. In an effort to effectively engage the new construction management student and provide a “real life” experience, the authors developed the Multicourse Undergraduate Learning Community (MULC).

The Multicourse Undergraduate Learning Communities (MULC) project is an instructional tool that utilizes a “real world” project that engages two or more courses in a curriculum. The project is selected based on its ability to simulate industry team relationships as well as reinforcing course learning objectives. With MULC projects, students from each course rely on one another for project deliverables, such as a highway design engineer would rely on a surveyor for land data.

The MULC project that was implemented utilized two courses: ETCE 2112 Construction Surveying and ETCE 4251 Highway Design and Construction. In this structure, the instructor driven project was replaced with a student driven model that simulates industry relationships. The project consisted of the design and layout of an access road for a new traffic pattern on campus. Each surveying group was paired with a highway design group to complete the project. The highway design teams (senior level) served as the project lead and each surveying team (sophomore level) was required to communicate with their highway design counterparts to collaboratively complete this project. This paper presents the development of a civil engineering technology/construction management MULC model and the results of the first delivery of a MULC project.

Introduction

As of December 2010, the Program for International Student Assessment (PISA) results revealed that U.S. students ranked 17th in science and 25th in math out of 70 other developed countries.[1] Unfortunately, these rankings are neither new to the science, technology, engineering and math (STEM) community nor have they varied significantly over the last decade. For years, the approach to the classroom in STEM disciplines has been the lecture/homework model that is based primarily on introvert learning (singular student). [2] The traditional STEM educational model is inconsistent with preferred learning styles of the current student population. According to Schroeder, “… new students, compared to their more traditional predecessors, prefer a high degree of personalism…. They adapt quite well to group activities and collaborative learning.”[3] Slavin, et. al., further point out that learning is improved or enhanced when students are engaged in challenging, related course materials.[4] These findings echo a trend toward more inductive or project based learning that has been documented in recent literature. [5,6,7,8,9,10,11,12] As such, new models are required to move the STEM disciplines forward.

Finger, et al. informs that rarely does a professor or a company plan to use the results generated from an engineering project performed by engineering student groups. Furthermore, the students work in an unstructured environment even if project roles have been assigned. [13] In addition, collaborative work or team assignments are frequently completed by students working independently during the project and combining work near the due date. This negates the intention of cross team communication and the group approach to solving problems. Regrettably, this model of team assignments where students work independently without the intended cross team communication is prevalent in STEM disciplines on many campuses nationwide. In an effort to overcome these collaborative learning shortcomings and engage the new STEM student, the authors propose the development of the Multicourse Undergraduate Learning Community (MULC).

The Multicourse Undergraduate Learning Community (MULC) process demands student engagement in a vertically integrated project scheme where student teams in multiple courses in the curriculum are interacting and utilizing others' work products during the term. Teams of students from one course are paired with student teams from other courses to complete a larger comprehensive project. As students progress in the curriculum, they move up through the hierarchy of courses, tasks and project responsibilities over a three year period. These multicourse teams are selected to model synergistic teams often found in industry and can include courses in surveying/highway design, biology/environmental design, or linear algebra/structural analysis. While these are examples of STEM courses combined within a civil engineering, civil engineering technology or construction management curriculum, the process can be readily extended to other STEM disciplines.

Project Rationale and Model

The purpose of this project is develop a vertically integrated learning community within the curriculum whereby students assume genuine leadership roles resulting in superior collaborative interaction and communication, improved time management and accountability, and enhanced outcome achievement throughout the undergraduate experience.

Multiple instructional methods provide value within the educational paradigm. When employed in concert, traditional, inductive, experiential and project based learning all have their place in the STEM classroom. Referring to Figure 1, traditional classrooms often operate autonomously with one another throughout the curriculum even when Course A is a prerequisite to Course B. Students may not be shown or recognize the linkages between the courses and the importance of Course A to Course B, C or D, for instance. Students who experience Course B during the completion of Course A should better appreciate and integrate the learning objectives of both courses.

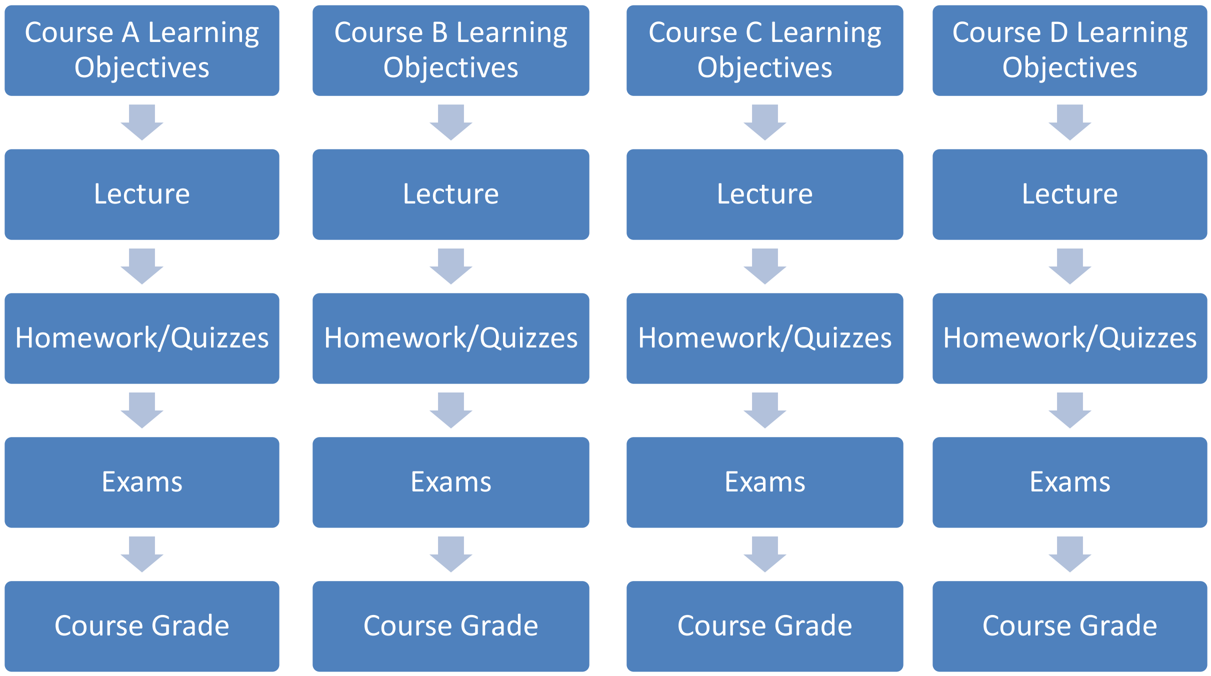

Figure 1. Traditional Classroom Structure

Taking these representative courses and introducing the Multicourse Undergraduate Learning Community (MULC), the course structure transforms to the structure illustrated in Figure 2. The multi-course project is a project that spans two or more courses in a curriculum, integrates / spans course objectives, and provides opportunities for structured vertical integration, collaboration and communication. Project teams in upper division courses assume leadership roles within the larger vertical project structure. Upper division teams rely on data, design, drawings or other information obtained or created by peers / teams in lower level courses. As students progress through the curriculum, their roles change and they assume roles and responsibilities previously held by their predecessors. In Figure 2, Course D (Highway Design and Construction) serves as the project leadership team which directs the other three courses on the required data and testing required. For this simulation, the leadership group is given a course project by the professor to initiate the MULC project. At this point, the leadership group (represented by the red arrows in Figure 2) engages the other three courses to perform testing (soils groups), data collection (surveying groups) and design (hydrology groups) for the MULC project. When each representative group is finished with their task, the deliverable is given to the leadership group to complete the project.

When choosing projects for MULC experiences, the instructors must look at the probability for success. Project scope for teams in each course must be carefully developed to assure opportunity for student success at each level. Scope of work is divided over multiple courses and adequate support structure for student deliverables is provided. Vertical student interaction begins early in the course to provide framework and responsibilities between the linked courses and teams. Instructor involvement includes careful attention to progress and deliverable dates. The instructor often serves as a mentor; however, the instructor should be well aware that they need to also serve as a safety net and/or offer guidance when appropriate. [14] As a means to act as a safety net for the project, the instructors completed the project prior to the start of the semester. If for any reason, one group could not perform to an appropriate level, the instructors could provide the necessary surveying or design data to the partner group. Furthermore, the courses are still traditionally organized in that each class has its own lectures, exams, homework, etc. The MULC project only replaces one graded metric in the course, not the entire course and each faculty member has equal input on the final MULC project grade.

While a number of projects can be used in this format, the authors of this proposal previously chose community/campus based projects to expose students to non-technical clients, develop empathy for social issues, stress the importance of creativity in engineering/construction, and explore the personal satisfaction from helping the community as described in work by Brackin and Gibson. [15]

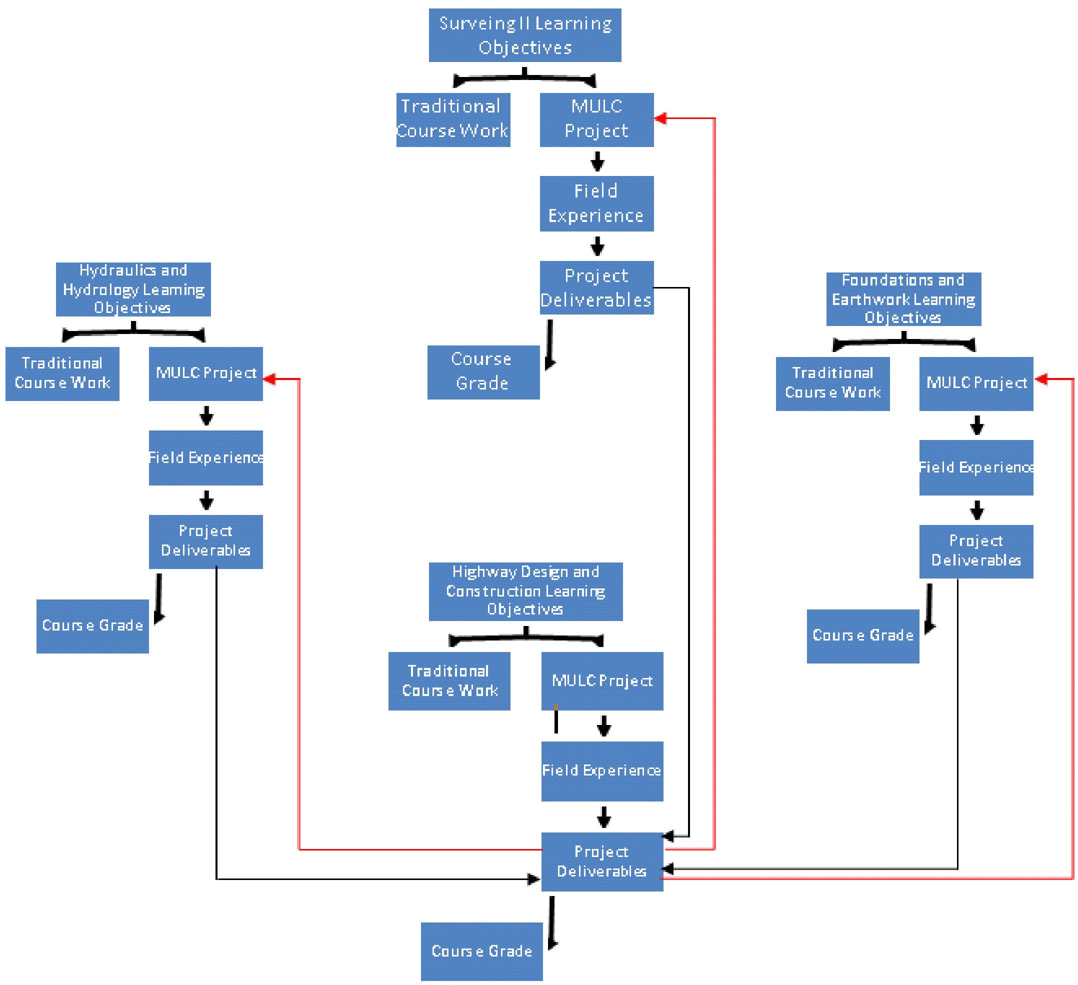

Figure 2. MULC Classroom Structure

MULC Implementation

The MULC project to be presented was implemented in two courses: ETCE 2112 Construction Surveying and ETCE 4251 Highway Design and Construction. Figure 3 illustrates the conceptual model used for this experiment. In this structure, the instructor driven project was replaced with a student driven model that simulates industry relationships. The project consisted of the design and layout of an access road located on the UNC Charlotte campus as illustrated by Figure 4. Each surveying group was paired with a highway design group to complete the project. The highway design teams (senior level) served as the project lead and each surveying team (sophomore level) was required to communicate with their highway design counterparts to collaboratively complete the project. The project consists of designing a connector road that will provide access around the proposed football facility. The MULC project engaged five course learning objectives for the Construction Surveying class and eight course learning objectives in the Highway Design and Construction class. These objectives are summarized in Table 1.

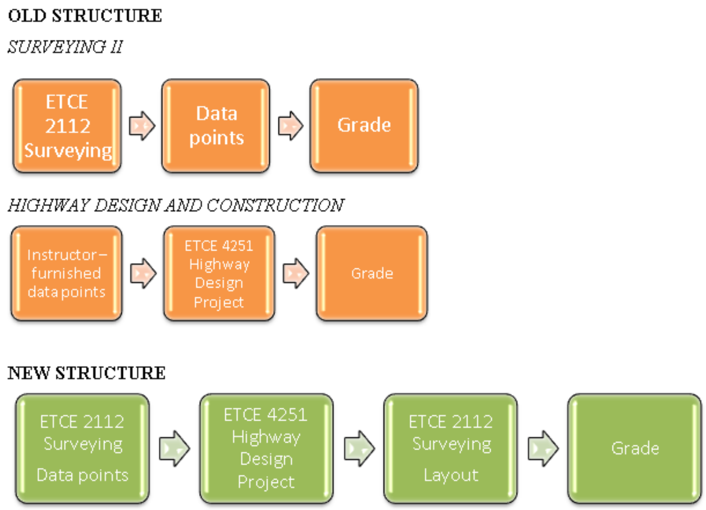

Figure 3. Previous Work - Surveying and Highway Design Project Structure

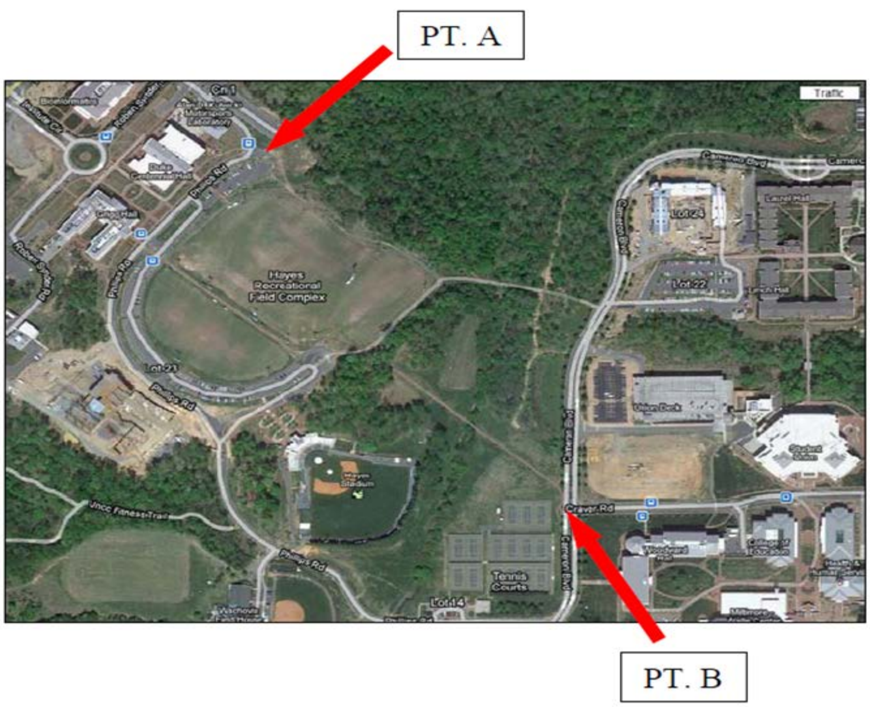

Figure 4. Surveying and Highway Design Project Location

Table 1. Representative Course Learning Objectives for MULC Project

Course	Representative Course Learning Objectives
ETCE 2112- Construction Surveying and Layout	1. Perform Subdivision and Boundary Surveys
	2. Develop property descriptions that includes deed research and historical property perspectives.
	3. Establish surface data
	4. Perform Geometric Highway construction surveys
	5. Calculate Cut and Fill Quantities
ETCE 4251- Highway Design and Construction	1. Analyze traffic flow characteristics and determine road design capacities.
	2. Calculate vehicle stopping distances and the required length of vertical and horizontal curves.
	3. Determine the appropriate cross-sectional elements of a roadway.
	4. Select the horizontal and vertical alignments of a roadway using given topographic information and design constraints.
	5. Calculate cut and fill earthwork volumes and mass diagrams.
	6. Perform construction survey layout calculations for roadways.
	7. Design flexible pavement sections using AASHTO, Asphalt Institute, and California design methods.
	8. Use the AutoCAD Civil 3D software program to develop engineering design drawings for a roadway project.

The surveying teams were responsible for collecting the necessary data required by the Highway Design and Construction teams to complete a roadway design. The surveying teams' duties included performing a property description of the site, collecting site data for design and then using the highway teams' design for collective layout of the project for construction. Typical surveying team results are presented in Figure 5. Likewise, the highway teams, using the surveying teams' work products, performed a traffic study, geometric design of the roadway, an intersection design and provided the surveying teams with construction layout data. A typical highway team final highway design is illustrated in Figure 6.

Conclusions

The purpose of the **M**ulticourse **U**ndergraduate **L**earning **C**ommunities (MULC) project is to implement a new integrative, interactive teaching strategy that allows the STEM student to take ownership of their education and promote synergistic learning throughout the curricula. By developing and investigating the efficacy of a vertically integrated learning community within the curriculum whereby students assume genuine leadership roles resulting in superior collaborative interaction and communication, improved time management and accountability, and enhanced outcome achievement throughout the undergraduate experience, much can be learned, communicated and leveraged from this project.

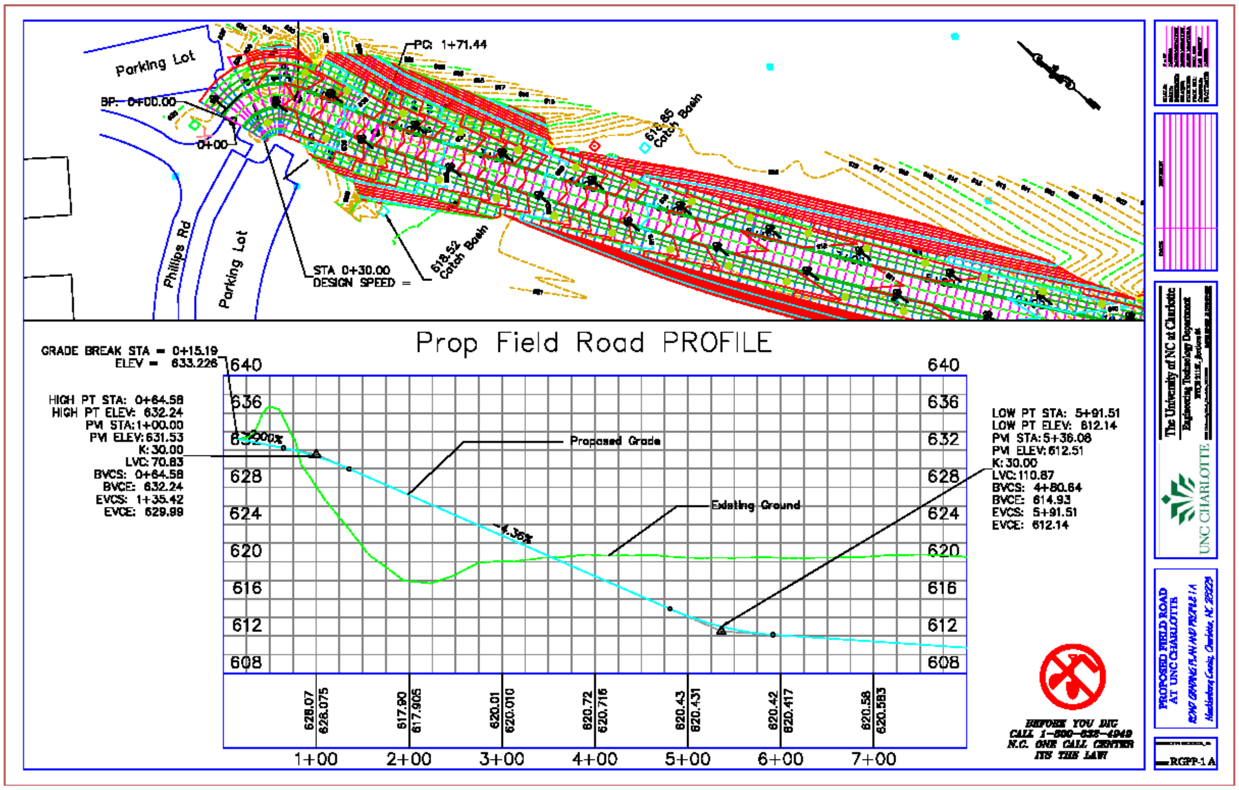

Figure 5. Representative Work Product - Construction Surveying II Student Team

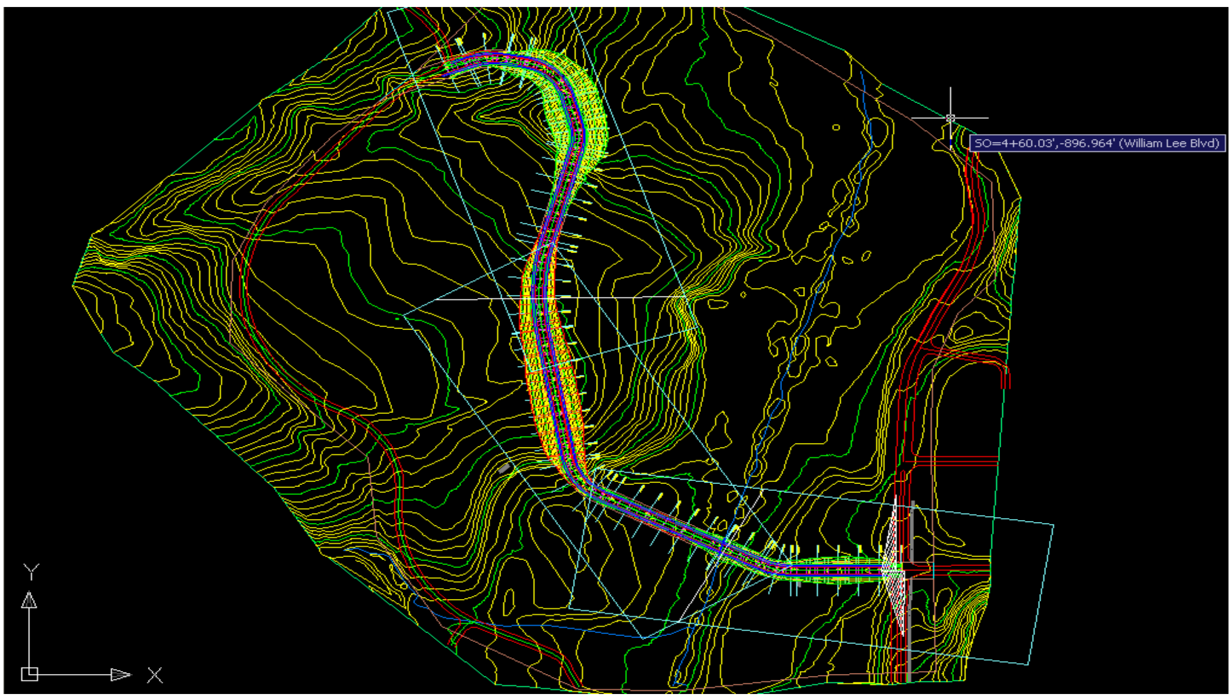

Figure 6. Representative Work Product - Highway Design and Construction Student Team

The assessment of student performance was based on linked learning objectives prenstented in Table 2. These linked learning objectives are prerequisite material for the subsequent class and increased performance in the prerequisite course should lead to increased performance in the subsequent course. These objectives were measured as a function of student performance on the final projects in ETCE 2112 and ETCE 4251 as part of a larger ABET assessment program. The final project is used to assess ability to solve technical problems and the ability of the students to effectively function in a team environment. As can be seen in Figure 7, student performance in the ETCE 4251 course increased during the years of 2010 (8 % average) and 2011 (12 % average) in which the MULC project was instituted. For ETCE 2112, no appreciable difference could be discerned from the data as to whether MULC projects positively impacted student performance other than the student evaluations lauding the course. It is the authors opinion, that the senior level course was embraced by the students and that there was significant ownership of the project at that level.

Table 2: Assessment of Knowledge Retention as it is Related to Learning Objectives

Learning Objective	Initial Assessment	Linked Learning Objective	Subsequent Assessment	Time Period between Courses
Perform Geometric Highway construction calculations and layout	ETCE 2112 Construction Surveying	Perform construction survey layout calculations for roadways.	ETCE 4251 Highway Design and Construction	2 semesters
Calculate Cut and Fill Quantities.	ETCE 2112 Construction Surveying	Calculate cut and fill earthwork volumes and mass diagrams.	ETCE 4251 Highway Design and Construction	2 semesters
Establish surface (contour) data	ETCE 2112 Construction Surveying	Select the horizontal and vertical alignments of a roadway using given topographic information and design constraints.	ETCE 4251 Highway Design and Construction	2 semesters

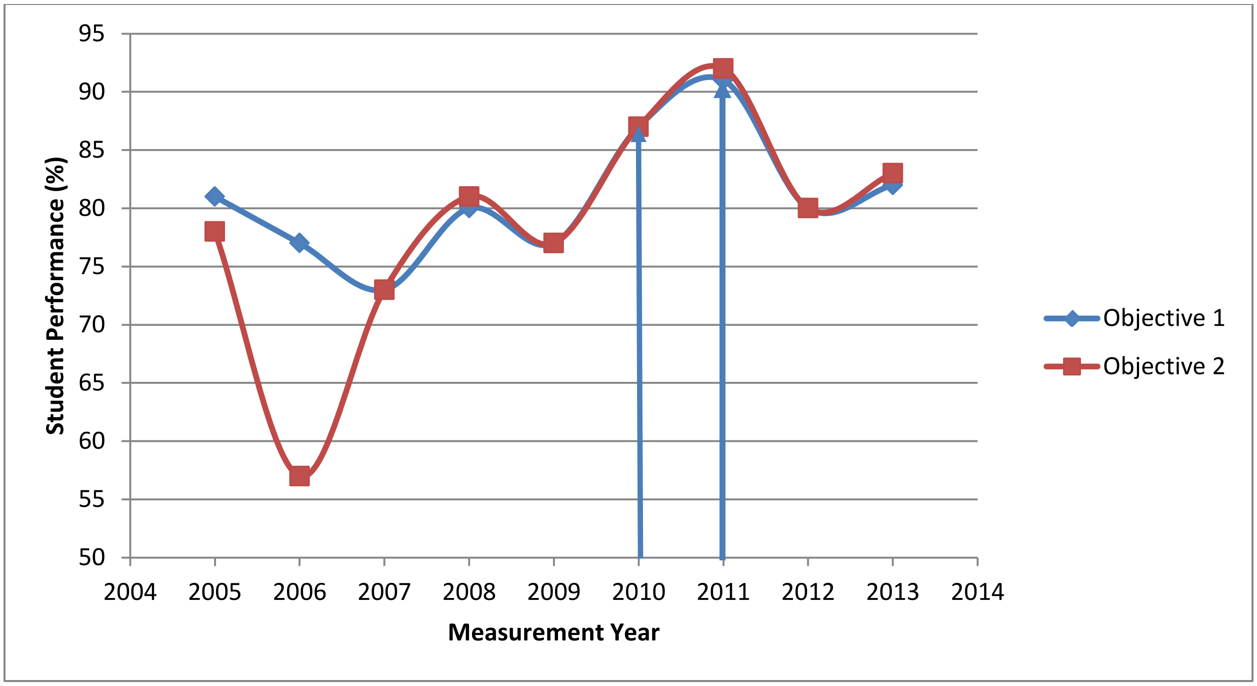

Figure 7. Longitudinal Analysis of Student Performance in ETCE 4251

Anecdotally, the student comments from each course evaluation supported a common theme; MULC is a challenging, yet rewarding and beneficial experience. Students described "highs and lows" of the project, long hours to produce deliverables, the importance of effective communication during design (one group had difficulty in expressing the exact data needed for the hydraulic analysis to their surveying group and several field trips were required), and the issues surrounding non-technical clients. However, as evidenced in student evaluations, they were very proud of their final product and requested more learning experiences in this format.

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