

## **AC 2010-58: DEVELOPMENT OF AN INTRODUCTION TO TRANSPORTATION ENGINEERING COURSE - USING EXPERIENCE-BASED LEARNING TO BRING AFGHANISTAN INTO THE CLASSROOM**

### **Nicholas Melin, United States Military Academy**

Major Nicholas Melin is an Assistant Professor in the Civil Engineering Department at the United States Military Academy, West Point, NY. He received his BS from the United States Military Academy and his PhD as a Rhodes Scholar from Oxford University, England. He has taught engineering mechanics and civil engineering design courses. His research interests include rapidly deployable structural systems and practical engineering education applications.

### **Richard Hallon, United States Military Academy**

Captain Richard Hallon is an Instructor in the Civil Engineering Department at the United States Military Academy, West Point, NY. He received his BS from the Florida International University and his MS from Carnegie Mellon University. He has taught engineering mechanics, construction management, and transportation engineering courses. His research interests include analysis, design, and education in the field transportation engineering.

### **Joseph Hanus, United States Military Academy**

Lieutenant Colonel Joseph Hanus is the acting Chair of the Civil Engineering Department at the United States Military Academy, West Point, NY. He received his BS from the University of Wisconsin - Platteville; MS from the University of Minnesota - Twin Cities; and PhD from the University of Wisconsin - Madison. He is an active member of ASEE and is a registered Professional Engineer in Wisconsin. His research interests include fiber reinforced polymer materials, accelerated bridge construction, and engineering education.

## **Development of an Introduction to Transportation Engineering Course - Using Experience-Based Learning to Bring Afghanistan Into the Classroom**

### **Abstract**

The development of an Introduction to Transportation Engineering Course in the Civil Engineering Program at the United States Military Academy is discussed, which includes experienced-based learning. Motivation for the development of the course structure is based on the fact that the graduates are in a unique position in comparison with their contemporaries at civilian universities. Each graduate of the program has a guaranteed job upon graduation as a platoon leader in the United States Army. Moreover, many will choose to become Corps of Engineers officers and step into construction management jobs as their first professional experience. The mission of the Corps of Engineers encompasses military construction around the globe and the management of a massive civil works program in both the United States and abroad. Given an officer population in the Corps of Engineers that comes from diverse educational backgrounds, it is also a reality that many of our graduates will be one of only a few degreed civil engineers in their first military unit. In general, Academy provides approximately half of the ABET accredited engineers to the US Army.

With so much riding on these young engineers' ability to leverage their education as soon as they graduate, the stakes are high for educators in the Academy's Civil Engineering department. Add to this the fact that many graduating seniors will deploy to Afghanistan soon after they complete their undergraduate education, and a situation exists where education must both prepare cadets to understand the theoretical foundation of engineering as well as its *effective practice in the deployed environment*. Though there are challenges associated with preparing engineers in training to take on such large tasks, there are advantages as well. Having knowledge of the specific jobs that our graduates will assume brings with it the potential to focus the "application" portion of the civil engineering curriculum and communicate with our customer, the Corps of Engineers, on what professional tasks a civil engineer must accomplish in a deployed environment.

This paper will discuss the development of the Introduction to Transportation Engineering course, from modeling the course structure based on a successful Construction Management Course to the specific development of experienced-based learning lessons. Underpinning the endeavor is the recognition that the true value of the structure and experienced-based learning experiences in the course is that students will achieve a higher level of development in the cognitive and affective domains – which are necessary to meeting the mission of the Academy and the Department. Furthermore, the authors believe that the selected content and overall approach in the introductory transportation engineering course presented in this paper is of interest to other institutions who are adding similar courses to their program.

## Introduction

The mission of the United States Military Academy (USMA) has evolved since the institution's inception in 1802<sup>1</sup>:

*To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country, and prepared for a career of professional excellence and service to the Nation as an officer in the United States Army.*

The Department of Civil and Mechanical Engineering is one of 11 departments at the Academy, and both the civil and mechanical engineering programs are ABET accredited. The mission of the Department of Civil and Mechanical Engineering parallels the Academy's mission, while focusing on educating and inspiring students in the fields of civil and mechanical engineering<sup>2</sup>:

*To educate cadets in civil and mechanical engineering, such that each graduate is a commissioned leader of character who can understand, implement, and manage technology; and to inspire cadets to a career in the United States Army and a lifetime of personal growth and service.*

The Department mission statement includes educating and inspiring, which align along a set of commonly accepted educational taxonomies; that is, Bloom's Taxonomy, which is based on the seminal work of the 1950's educational committee chaired by Benjamin Bloom. The committee established a set of taxonomies in three domains of learning: cognitive, affective and psychomotor. The cognitive domain taxonomy is widely accepted in many fields and has been identified as, "arguably one of the most influential education monographs of the past half century."<sup>3</sup> The taxonomies are a language that describes the progressive development of an individual in each domain and are defined as follows<sup>4</sup>:

- Cognitive: of, relating to, being, or involving conscious intellectual activity.
- Affective: relating to, arising from, or influencing feelings or emotions.
- Psychomotor: of or relating to motor action directly proceeding from mental activity.

A set of development levels for each domain are shown in Table 1 based on work by Bloom (1956)<sup>5</sup>, Krathwohl et. al. (1973)<sup>6</sup>, and Simpson (1972)<sup>7</sup>, respectively. Each column shows the levels in each domain, from the simple at the top, to the more complex at the bottom.

*Table 1. Domain Levels*

<b>Cognitive Domain<sup>5</sup></b>	<b>Affective Domain<sup>6</sup></b>	<b>Psychomotor Domain<sup>7</sup></b>
Knowledge	Receiving	Perception
Comprehension	Responding	Set
Application	Valuing	Guided Response
Analysis	Organization	Mechanism
Synthesis	Characterization by a Value Complex	Complex Overt Response
Evaluation		Adaptation
		Origination

The authors recognized that their institutional mission statement expects both education (cognitive domain) and inspiration (affective domain) in their program. Furthermore, the authors believe that the engineering education profession is setting an expectation for student development in both of these domains. In particular this trend is evident in the American Society of Civil Engineers (ASCE) Body of Knowledge 2 (BOK2)<sup>8</sup> and has been studied in detail by the third author<sup>9-13</sup>. As such, courses in the Academy's civil engineering program strive to develop their students in both domains.

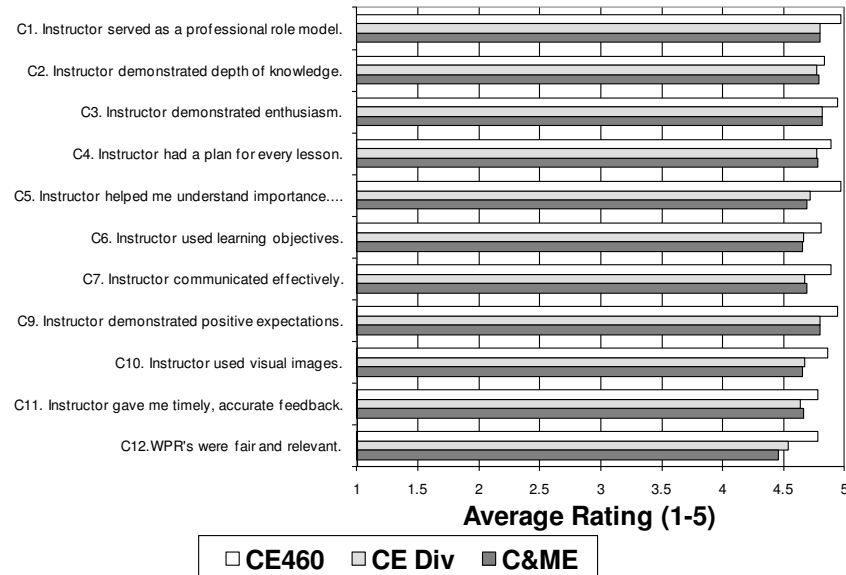
This paper will discuss the development of a new Introduction to Transportation course at the Academy, which includes an Experienced-Based Learning approach. The structure of the course followed an already successful course – Construction Management, which will be briefly discussed first to appreciate the motivation to structuring the new course in a similar manner. The authors believe that the approach in both these courses develops students in the cognitive domain, while also motivating them to a higher level in the affective domain with respect to their new knowledge.

### **Construction Management Course: First Step Toward Experience-Based Learning**

The Civil Engineering program placed a high emphasis on educating and inspiring students in construction management skills to achieve program objectives and outcomes, and to meet the needs of our constituents<sup>14</sup>. In the program's Construction Management course the students spend approximately 40% of the lessons learning the basic fundamentals of construction management, paralleling their textbook chapters. These fundamentals include delivery methods and contracts, estimating, and scheduling. The remainder of the course applies these fundamentals in a construction management exercise using *K'NEXs* (20%) and an exercise in the design and construction of a military base camp (40%)<sup>12</sup>. This approach is not revolutionary and has similarly been done in other programs<sup>15</sup>. The first author was a guest lecturer in the fall term of 2009 and presented his experience with base camp design and construction in Afghanistan. This approach of fundamentals first, followed by applications was assessed.

End-of-course surveys are completed at West Point for all courses and proved to be effective in assessing course development and teaching effectiveness. The survey includes quantitative questions, which can be compared to previous terms and across the Civil Engineering Division and the Department (of Civil and Mechanical Engineering). Figure 1 is the quantitative data from the last offering of the Construction Management Course. Although the questions are prefaced mostly with "Instructor...", they do address course organization, content, and how the students perceive the instructor's knowledge base – which is important for the approach in the course. The course performed well compared to previous terms and in comparison to the Division and the Department. These results were positive – indicating the course structure was effective and well received by the students.

**Term 09-2 Course Feedback  
CE460, Construction Management, Spring 2009  
C&ME Questions**



*Figure 1. Course-End-Feedback, Construction Management Course*

In addition to the quantitative data, qualitative questions are also asked of the students. In these responses, the students clearly appreciated the base camp portion of the course, which was the application portion. For example, in response to the question, “What did you learn in the course that will be of help to you in the future?”, 29% of the 56 students commented on the base camp portion of the course as the best for preparing for the future. Comments included the following:

*What did you learn in the course that will be of help to you in the future?*

- *How to develop base camps*
- *If I ever have to help plan and build a basecamp, I'm prepared.*
- *Base camps are no joke.*
- *How to manage a construction project and what goes into making a base camp.*
- *The components of basecamp design will definitely be of use in the future.*
- *Understanding the work phases and processes that engineers have to go through to set up a base camp, and understanding all of the infrastructure design that has to go into a base camp. I'm sure that understanding all of that will help out a lot in the future.*
- *An appreciation for the design and work that goes into making our lives easier when deployed at bases and FOBs around the world.*

Based on the success of the construction management course, a similar structure was considered in the development of the new Introduction to Transportation Engineering course. In developing the new course, the authors realized that there was more to the structure; that is, it was more than simply establishing fundamentals and then applying them in exercises.

## Development of the Introduction to Transportation Engineering Course

In the program's ABET evaluation process it was determined that a transportation engineering course was necessary to meet the needs of our constituents<sup>14</sup>. Given the limited space in the program, it was determined that this need would be best met with an introduction level course. The program already included some roadway engineering in the Site Development course<sup>9</sup>; as such, the new course could be an elective and provide an opportunity for some students to develop transportation skills. In the first offering, over half of the eligible students selected the new Introduction to Transportation Engineering as one of their three electives. The development of the course was very timely as the program had just been assigned a military instructor who had worked in the private sector as a transportation engineer prior to enlisting in the military – the second author. Additionally, at the time of the course development the *National Transportation Engineering Education Conference* was held at the Portland State University, on June 22-23, 2009. The third author attended and was able to effectively vet many of the ideas for the course development. The course was developed based on the success of the Construction Management course, the author's experiences, and the trends in the transportation engineering education community. The course is detailed in what follows.

### Course Topics and Relevancy

The West Point Introduction to Transportation Engineering Course will cover the following subject material:

- Introduction to Transportation: An introductory discussion of the different elements that affect our perception of transportation systems; a summary of the history and development of transportation in the U.S. with a closer view at its highway system; the different modes of transportation available; current trends our country is following, in terms of resource investment; and how our established use of these systems affects our lives.
- Vehicle and User: An analysis of the capabilities and limitations that a vehicle and its driver bring into play as they enter the road system. We study the competing interaction between the engine capabilities of a moving driven vehicle and a slowing resistance from the elements that surround it, namely, the road surface, the air in front of the vehicle, and even gravity. We also study the time and distance it takes for a driven vehicle to stop; from the time its driver makes the decision to stop the vehicle to the point in time the vehicle reaches a complete stop.
- Road Design: A description of the established processes used in industry to design the path a stretch of road may follow. Students learn how to design a portion of a road system while taking into account constraints in both the horizontal and vertical planes.
- Pavement Design: Presentation of main types of pavements the industry uses for road construction. Students are exposed to procedures and considerations for Superpave design, rigid and flexible pavements.
- Traffic Flow and Queue Theory: One of the most important topics in the field of traffic engineering, this section introduces traffic flow, traffic distribution models, and an analysis of queuing as observed in traffic behavior.

- Level of Service of Freeways and Highways: This section explains the current industry standards for measuring the efficiency of sections of roads in terms of delay and driver's sense of comfort and safety.
- Traffic Signal Analysis and Design: The culmination of the theory portion of this course, this section includes the study of the main elements of a traffic signal, how to measure its serviceability, and how to design its timing to maximize its efficiency in terms of driver delay.
- Experience-Based Learning (EBL) – Design and Construction of a road in Afghanistan: Set of problems and activities progressing in complexity and following the timeline of the construction process while applying concepts and theory received earlier in the course.

Table 2 shows a list of topics, ranked by level of importance as determined by transportation engineers in the transportation industry. This survey was taken by Rod Turochy in 2004 and involved 77 practicing transportation professionals, representing local and state government, and private industry, specializing in different areas of transportation<sup>16</sup>. Table 2 also shows the level of focus provided by this course. Topics with multiple lessons devoted to it, together with assignments, are marked as major topics; minor topics have less than one lesson dedicated, and may or may not be included in assignments. Additionally, topics covered in the project-based portion of this course are marked EB.

*Table 2. Industry-Relevant Transportation Topics<sup>16</sup>*

<b><i>Topic</i></b>	<b><i>Rank</i></b>	<b><i>Course Focus</i></b>
Geometric Design of highways	1	M
Description of Transportation Systems	2	m
Highway Capacity Studies	3	M
Land Use/Transportation Interaction	4	---
Traffic Flow Characteristics	5	M
Transportation Planning	6	m
Traffic Safety	7	m
Intersection Design	8	M
Traffic Control Devices	9	PB
Intelligent Transportation Systems	10	m
Transportation Systems Management	11	---
Economics of Transportation	12	m
Operational Characteristics of Modes	13	m
Mass Transit	14	m
Evaluation Techniques	15	m
History / Development of Transportation	16	m
Vehicle Operating Characteristics	17	M
Statistics applied to Transportation	18	M
Transportation Legislation	19	---
Transportation Materials	20	PB
Construction Procedures	21	PB

*“M” Major; “m” minor; “EB” Experience-based; “---” Not covered*

Table 2. Industry-Relevant Transportation Topics (Continued)<sup>16</sup>

<b><i>Topic</i></b>	<b><i>Rank</i></b>	<b><i>Course Focus</i></b>
Contracting Procedures	22	---
Airport Planning	23	---
Specifications	24	m
Pavement Management	25	PB
Maintenance of Facilities	26	---
Human Powered Transportation	27	m
Earthwork Operations	28	PB
Ports and Harbors	29	---
Pipelines	30	---
Belt Conveyors	31	---

*“M” Major; “m” minor; “EB” Experience-based; “---” Not covered*

As seen above, from a total of 31 topics, six topics have a major role in this course, eleven play a minor role, five are covered in the project-based portion of the course, and nine are not covered. From the top ten topics, four have a major role, four play a minor role, and one is covered in the project-based portion. Two topics, Land Use, although ranked high in Turochy’ survey, is considered too specialized, and the decision was made to not include it; the level of involvement of our students in the field of transportation land use as young officers is expected to be minimal when compared to other topics given a major focus in this course.

Conversely, two topics not as high ranked, vehicle characteristics and transportation statistics are covered through various lessons within our course. The first topic plays an important role in the design of safe driving conditions in terms of stopping site distance, while the latter is the foundational basis for the analysis of traffic distribution and queuing.

The experience-based portion of this course should not follow the current industry trends, since the main focus of these lessons is to prepare students for transportation-related work while deployed; it is projected this type of work will entail tasks such as design and construction of two-lane roadways, pavement design/maintenance/repair, and earthwork operations. Although these areas are not considered as critical in the U.S. (as seen in the table), they are essential to the reconstruction efforts the US military is heavily involved in throughout the world.

This course focuses in different areas of transportation theory and touches on current relevant topics as established by the transportation industry, while at the same time it is aimed at preparing our students for the high likelihood of heavy involvement in transportation-related work during deployments.



## Experience-Based Context for Course

A considerable portion of the course developed focuses its didactical effort around the design and construction of a road in a deployed environment, a realistic and very likely problem our students will face once they are part of the US Army workforce. The design and construction of a road is much more complex in a deployed environment due to a number of factors not present or more easily manageable in a more conventional setting: Security concerns, cultural and social considerations, material availability (or lack thereof), contractor expertise and availability, mission requirements, and commander expectations, are just a few of the added concerns which make this problem well suited for maximum learning opportunities through a Problem-Based Learning (PBL) approach.

A good problem for use in this context is described as being complex, ill-structured, and open-ended to foster flexible thinking; and being realistic and resonate to students' experiences to support their intrinsic motivation<sup>17</sup>. These characteristics in turn can increase opportunities for group discussion over potential solutions, offers instances for instructor feedback to help students evaluate or even steer learning when needed, and allows self-reflection of the learning that is taking place<sup>17</sup>.

Ill-defined problems have such a positive view as learning tools for engineering that the NSF-funded Center for the Study of Problem Solving created a case library of engineering experiences, based on the premise that engineers generally solve problems in the workplace by remembering similar problems' histories and applying the lessons learned from those cases to new ones<sup>18</sup>. For the creation of this library, 106 practicing engineers were asked to recall a typical workplace problem they had to solve at some point in their careers and provide insights on how they analyzed the problem, generated solutions for it, and the level of success of these solutions<sup>18</sup>.

Instructors also play a key role in PBL; Hmelo-Silver (2004) states that they should they be considered facilitators, serving as motivators, guiding students through various stages of PBL, monitoring the group experience, and aiding in self-reflection through well-directed questioning to individual cadets. She even establishes a *wandering facilitation* strategy that presents an instructor with alternative tools to allow facilitation of a bigger number of groups<sup>17</sup>.

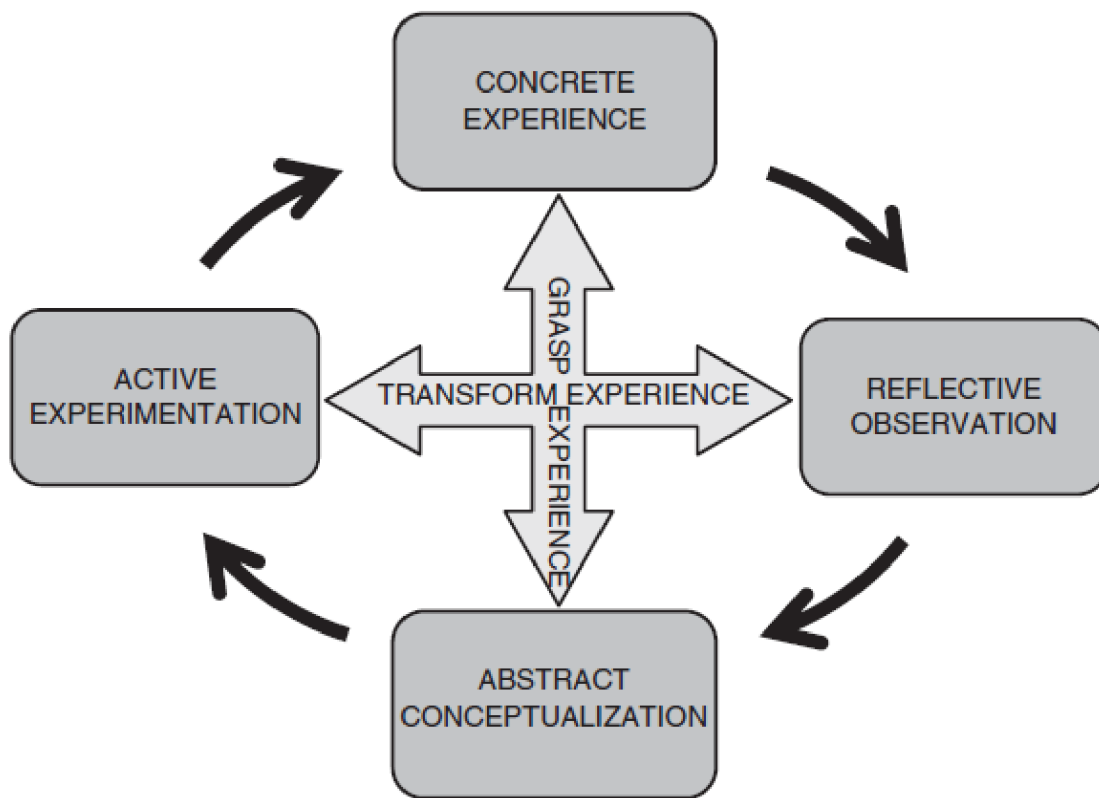
Another instructor quality that positively influences the PBL experience is the instructor's experience and expertise in the problem used. These qualities are considered invaluable as inferred by the fact that problems for the NSF case library were collected exclusively from a pool of practicing engineers; we cannot underestimate the potential benefits inherent in high level of expertise in the subject matter being taught.

The unique level of experience instructors have on the subjects to be taught can benefit the course at various levels:

- It can ensure cadets recognize the instructor's mastery of the material early on; this aids in lowering skepticism, and enhances trust toward the instructor's abilities to teach.

- It allows the instructor to focus more in his facilitator role during PBL; in turn, focus on the material can be relegated to a secondary stage without any loss of confidence from the instructor, or risk of losing control of the class.
- It gives the instructor the ability to improve or even improvise learning paths, which in turn can maximize the freedom allowed to the students for self-learning opportunities.

The whole PBL/EBL approach merits further analysis; Hmelo-Silver describes PBL as “focused, experiential learning organized around the investigation, explanation, and resolution of meaningful problems”<sup>17</sup> (Barrows 2000, Torp & Sage 2002, as cited by Hmelo-Silver 2004, p. 236). Generally, experiential learning follows the Experiential Learning Cycle as depicted in Figure 2 below:



*Figure 2. The Experiential Learning Cycle<sup>18</sup>*

A. Kolb and D. Kolb (2009) define Experiential Learning Theory as “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience”<sup>19</sup> (D. Kolb 1984, as cited by A. Kolb & D. Kolb 2009, p.298). As Kolb (2009) explains it, during experiential learning students can grasp experiences in a concrete fashion (actual personal experiences) and through abstract conceptualizations (simulations). Then these experiences are transformed by reflective observation and active experimentation, resulting in a deeper understanding and ultimately in knowledge.

Furthermore, EBL instruction can be further recognized by analyzing the focus given to the student while setting up the learning experience<sup>20</sup>:

- Students engaged in EBL are involved through their senses, feelings, and intellect, at varying levels.
- Students can recognize and relate lessons to personal learning experiences.
- Students can reflect upon earlier experiences and transform them into deeper understanding.

During the EBL portion of the course, the process of learning for students is visualized as follows:

- 1- Students will grasp experiences from problems presented during class; these will generate from the concrete experiences brought by the instructor, and presented for abstract conceptualization by the students.
- 2- The instructor will present background information regarding the situation, characteristics and other aspects pertinent to the full comprehension of the problem. This will be done with care to keep the problem ill-defined and open-ended to better engage the student.
- 3- Students will then transform these experiences through problem solving activities such as brainstorming sessions, group discussion, and reflecting upon the problem while applying different subjects learned earlier in the course, to finally come up with a tentative solution for assessment.
- 4- Instructor assessments will in turn create more self-reflection, finishing the transformation of these experiences into knowledge.

A major portion of the course (60%) includes the EBL experience. Since graduates of the civil engineering program at West Point will all join the Army upon graduation, it makes sense to ground learning in examples drawn from construction missions occurring overseas. Also, since the majority of civil graduates choose to be Army engineer officers, it is also possible to communicate with the Army Corps of Engineers to determine what skills and knowledge are considered most critical.

The operational environment that will greet West Point graduates as they deploy to Afghanistan or Iraq is one full of uncertainty. It requires flexible engineer-thinkers who can take the tools provided to them in their engineering education and apply them with little expert oversight on large projects. As each of our students reaches their first assignments with an engineer unit slated to or already deployed overseas, they will be confronted with three important facts:

- 1- They will among only a handful of people in their 400+ Soldier unit with an ABET accredited civil engineering education. Graduates will be placed in roles supervising and managing large construction projects almost immediately upon arrival, and senior leaders will trust their judgment. The first author was the primary construction manager of a 22 million dollar project within two months of joining his first deployed unit.
- 2- The magnitude of the construction mission in Afghanistan alone is staggering. Between 2002 and 2007, over 1.7 billion dollars was committed to expanding and reconstructing the Afghan road network<sup>21</sup>. With an increased commitment to Afghanistan in coming years, it is realistic to believe that efforts to build roads will accelerate and that Army engineer officers will be involved.

- 3- The standardized problem statement to which many students become accustomed during their education simply does not exist in Afghanistan. The road construction missions graduates will execute are often ill-defined, as topographic, hydrological and cultural data in isolated areas is not available.

Given these facts, the objective of the EBL component of the Transportation Course is designed to confront students with open-ended transportation problems that require them not only to grasp specific elements of the course content, but also to synthesize elements of their engineering education presented in other courses that pertain to actually building a road in Afghanistan.

The construction problem that acts as the thread for the EBL component of the transportation course is the design of a two lane gravel road between the cities of Kandahar to Tarin Kowt in Afghanistan, as shown in Figure 3 below. This mission was executed by the 864<sup>th</sup> Engineer Combat Battalion in 2005. Wherever possible, actual military orders, design specifications and pictures from that mission are used to demonstrate the practicality and relevance of the material to the student. Additionally, as the first author worked on the project it was possible to discuss actual methods used on the project when instructing students, highlighting those that worked well and candidly discussing situations where inadequate design occurred.

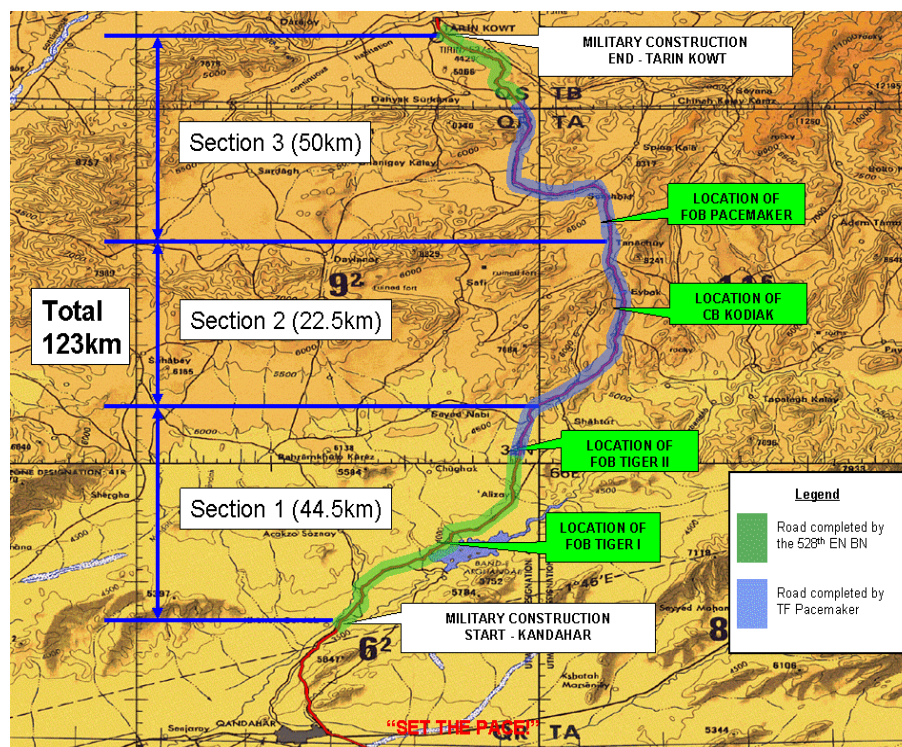


Figure 3. The Kandahar to Tarin Kowt Road Construction Project

Over a ten lesson period, student teams apply the tools they learned at the beginning of the course to a deployed engineer mission. They receive a set of military maps and an operational briefing. The first assigned task is to plan the reconnaissance of the road, including a tentative alignment, locations of drainage structures, and a rough material takeout. Rather than

immediately guiding them through an acceptable process, students must fully define the problem themselves. During the next lesson, a guided discussion occurs, where practical lessons from the actual conduct of the reconnaissance are presented along with student results. Students then have the opportunity to reflect, and make any changes before moving forward to the next component of the design. With each lesson beginning with a review of construction decisions that the student made and ending with a new problem to consider, students have the opportunity to both execute a design and refine it as part of the learning experience.

Students progress during subsequent lessons through the process of determining a correct road alignment by refining their initial plans and using the design methods presented early in the course. Problems such as designing a vertical or horizontal curve are made relevant through the use of an actual construction problem, and issues seen when executing the actual design mission are considered. An example of this is the importance of understanding the irrigation methods used by local farmers. In 2005, the road builders working on the Kandahar to Tarin Kowt Road experienced significant delays because heavy construction equipment disrupted the underground irrigation systems used by local people. Known as Karezes, these tunnels are critical to watering crops in arid areas. Road designers, unaware of these structures, plotted the alignment of the road over them with no construction restrictions. When bull dozers disrupted the underground tunnels, local leaders soon arrived to express their displeasure, as shown in Figure 4.



*Figure 4. An uncovered Karez Drainage System and the unhappy Local Elder*

Practical, Afghanistan-specific scenarios are both interesting to students and illustrative of the importance of considering more than a standard design procedure when laying out a road. Cultural considerations are present when building in any location, but tying the lesson to a scenario students might soon face provides them with experience-based knowledge they can carry forward in their careers.

A critical component to the EBL lesson structure is the introduction of non-standard design problems that require students to develop and refine a design based upon multiple factors. It is in these lessons that students are required to synthesize the material they have been taught in prior courses, apply it to a given problem, and then evaluate the efficacy of theirs and other groups' plans. An example of this is the lesson focused on the effect of water on their road design.



Though drainage structures are not typically a facet of an introductory transportation course, one cannot actually build a road without understanding and accounting for drainage. Students in the Transportation Course are in their final semester as undergraduates, so they have already learned about culverts in their Hydrology Course. In designing their road, students must consider likely locations where drainage structures may be required and develop appropriate, conservative estimates for the materials necessary to accomplish their drainage plan. In absence of hydrological data and a complete survey the *will not* have the necessary data to conduct a rigorous design. Rather, they will need to employ what engineering tools they can to define the problem and make conservative estimates. Facilitation of this process allows the instructor to discuss both the use of drainage structures and water control measures away from the road bed, such as check dams and diversion ditches that can channel and slow down water.

One problem for which a full lesson is devoted is that of the large drainage area. As students lay out their roads, there are numerous locations where it is clear that a bridge will be necessary due to the anticipated flow rate and width of the drainage pattern. Discussion is initially focused on what it takes to build a bridge, and potentially how long the drainage patterns the students have identified as requiring them will be left unaltered. As students consider this, a the facilitator shares a vignette that discusses an improvised explosive device (IED) detonation in one of these large drainage areas that resulted in two Soldier deaths in the 864<sup>th</sup> Engineer Battalion during the construction of the Kandahar to Tarin Kowt Road. Dry river beds are the number one location where insurgents place IEDs because of the ease of burying and concealment.

The real-life, experienced based problem is then posed to the students: If we have to build a hardened roadway across this large drainage area to prevent coalition casualties, how can we build it to ensure that it lasts the period of time required for emplacing a bridge? Clearly a low water crossing or causeway is inappropriate for the long term, but we must do something to mitigate the IED risk. The development of the solution then mirrors the actual steps taken by the 864<sup>th</sup> in developing an interim solution, starting with an initial design provided by higher headquarters that the students will look at and evaluate to determine its efficacy. Students may request information, and during the lesson discussion consideration is given to the capabilities of local craftsmen, the importance of construction inspection and the factors that could, potentially affect the crossing like scour and flooding, as shown in Figure 5 below.



*Figure 5. The effect of Scour on a Low Water Crossing, and installation of a Sloped Spillway*

Consideration of these and other factors surrounding road construction enriches the student's understanding of road construction as an integrated engineering task which incorporates knowledge of transportation engineering, hydrology and even structural design to arrive at an acceptable solution. As students complete EBL component of the course, teams brief their commander on their road design, with the opportunity for student groups to see how others in their class solved the design problem.

As an end state, students will see how the various tasks they accomplish while designing the Kandahar to Tarin Kowt Road integrate together into an executable plan. While there is the possibility of an inadequate design, students will see that there are many acceptable solutions. They will also understand the effects of failing to account for the potential engineering and non engineering issues that arise when actually building a road in Afghanistan.

By integrating practical experiences into instruction and facilitating student discovery rather than presenting material, the Introduction to Transportation course aims to provide students both the technical fundamentals required to correctly design a road and the experience and context to fully understand how to build it in a deployed environment. As observed in the field by the first author, young engineers tasked with large projects in a deployed environment tend to have the skills necessary to see the various components of a large construction problem, but stall when presented with small obstacles or inadequate information. They are inexperienced in seeing the project as a whole and developing alternative courses-of-action. This inflexibility comes, at least in part, from a lack of familiarity and experience with open-ended problems. Application of EBL learning techniques is an excellent way of building the confidence of the student in such situations. This experience is only enhanced when the open-ended problem that is chosen is based material relevant to the student's future career.

## Conclusions and Next Steps

The purpose of this paper was to discuss the development of a new Introduction to Transportation Engineering course, which incorporated experienced-based learning. The course structure was modeled after a successful Construction Management course, and the content developed based on the authors' experiences, and the trends in the transportation engineering education community. Understanding that graduates of the Civil Engineering curriculum at West Point will participate in the Global War on Terrorism and will likely design and manage large road construction projects, the emphasis in the experience based portion of the course on Afghanistan was timely and appropriate.

While the initial implementation of this method has been successful, the authors acknowledge that more work is needed to both assess the efficacy of the Introduction to Transportation Engineering Course and refine its content. The following steps for the coming academic year are proposed:

- The development of a better assessment process to determine are the students truly developing in both the affective and cognitive domain in the new course. This will likely involve the Academy's course-end-feedback survey system and potentially the process for in-class assessment, such as outlined by Nambisan in a similar course at University of Nevada – Las Vegas.<sup>22</sup> It is essential that the course structure and experienced-based learning be assessed relative to the established taxonomies.
- The careful assessment of the EBL approach. The authors have chosen this approach based on experience in and research into various learning experience alternatives; however, every institution and course is different, and the authors are continually searching and considering different approaches. A potential process of particular interest, as presented by Jonassen et. al., would seek to reach out to the entire US Army to develop a cataloged library of transportation projects from Army engineers as means to further broaden the instructor's experience basis.<sup>18</sup>
- Further involvement in the transportation education community, such as the *National Transportation Engineering Education Conference* is critical. The Academy may be able to provide an ideal environment to further vet ideas for transportation engineering education.

By using the practical problem of designing a road and structuring the presentation of material around the student's efforts, the authors aim at providing relevant experience to students that will prepare them for future challenges. As an end-state, it is hoped that teaching methods, as used in Construction Management and the Introduction to Transportation Course, will facilitate the development of graduates who have reached the highest levels of Blooms taxonomy and are able to synthesize, evaluate and characterize the efficacy of the construction methods they utilize.



## Bibliography

1. United States Military Academy (2008). *Mission Statement*. <http://www.usma.edu/mission.asp> (accessed Jan 1, 2008).
2. Department of Civil and Mechanical Engineering, USMA (2008). *Mission Statement*. <http://www.dean.usma.edu/departments/cme/CME%20Home/mission.htm> (accessed Jan 1, 2008).
3. Anderson, L.W. and L.A. Sosniak (1994). "Bloom's taxonomy: A forty-year retrospective." Ninety-third yearbook of the Nation Society for the Study of Education (NSSE), Part II. University of Chicago Press.
4. Merriam-Webster's Online Dictionary (2008). <http://www.m-w.com/dictionary> (accessed Jan 1, 2008).
5. Bloom, B.S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co., Inc.
6. Krathwohl, D.R., B.S. Bloom, and B.M. Bertram (1973). *Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook II: Affective Domain*. New York: David McKay Co., Inc.
7. Simpson, E. (1972). *The classification of educational objectives in the psychomotor domain: The psychomotor domain*. Vol. 3. Washington, DC: Gryphon House.
8. ASCE (2008). *Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century – Preparing the Civil Engineer for the Future*. Second Edition. Reston, Virginia: American Society of Civil Engineers.
9. Caldwell, C., Hanus, J., Chalmers, J.(2009), "Integration of Information Technology Software in a Civil Engineering Program, *Proceedings of the 2009 Annual Conference of the American Society for Engineering Education (ASEE)*, Austin, TX.
10. Saliklis, E., Arens, R., Hanus, J. (2009), "Teaching Architects and Engineers – Up and Down the Taxonomy," *Proceedings of the 2009 Annual Conference of the American Society for Engineering Education (ASEE)*, Austin, TX.
11. Hanus, J., Hamilton, S., Russell, J. (2008). "The Cognitive and Affective Domain in Assessing Life Long Learning." *Proceedings of the 2008 Annual Conference of the American Society for Engineering Education (ASEE)*, Pittsburg, PA.
12. Himes, J., Bruhl, J., Hanus, J. (2008). "Teaching Engineering to the Disinterested: A Case Study in Teaching Engineering Principles to Non-Engineering Majors." *Proceedings of the 2008 Annual Conference of the American Society for Engineering Education (ASEE)*, Pittsburg, PA.
13. Hanus, J. P., Russell, J. S., (2007). "Integrating the Development of Teamwork, Diversity, Leadership, and Communication Skills into a Capstone Design Course." *Proceedings of the 2007 Annual Conference of the American Society for Engineering Education (ASEE)*, Honolulu, HI.
14. Meyer, F., Conley, C., Hanus, J., Klosky, L. (2008). "A Global Curriculum to Support Civil Engineering in Developing Nations." *Proceedings of the 2008 Annual Conference of the American Society for Engineering Education (ASEE)*, Pittsburg, PA.
15. Williams, K. and Pender, G. (2006). "Problem-Based Learning Approach to Construction Management Teaching." *Journal of Professional Issues in Engineering Education and Practice*, 128: 19-24.

16. Turochy, R. (2006). "Determining the Content of the First Course in Transportation Engineering." *Journal of Professional Issues in Engineering Education and Practice*, 132 (3): 200-203.
17. Hmelo-Silver, Cindy E. (2004). "Problem-Based Learning: What and How Do Students Learn?" *Educational Psychology Review*, 16 (3): 235-266.
18. Jonassen, D., Strobel, J., Lee, C. (2006). "Everyday Problem Solving in Engineering: Lessons for Engineering Educators." *Journal of Engineering Education*, 95 (2): 139-151.
19. Kolb, A., Kolb, D. (2009). "The Learning Way: Meta-cognitive Aspects of Experiential Learning." *Simulation & Gaming*, 40 (3): 297-327.
20. Andresen, L., Boud, D., Cohen, R. (2000), "Experience-Based Learning". In Foley, G. (Ed.). *Understanding Adult Education and Training*, 2<sup>nd</sup> Ed., Sidney: Allen & Urwin, 225-239.
21. United States Government Accountability Office, (2008). "Afghanistan Reconstruction: Progress Made in Constructing Roads, but Assessments for Determining Impact and a Sustainable Maintenance Program Are Needed." GAO 08-689, 9.
22. Nambisan, S. (2002). "A Team Oriented, Case-Based Approach for a Transportation Engineering Course." *Proceedings of the 2002 Annual Conference of the American Society for Engineering Education (ASEE)*, Montreal, Canada.