Incorporating Different Design Aspects of Land Transportation in the Introductory Level Undergraduate Transportation Engineering Course

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Abstract
Most undergraduate civil engineering programs in the United States offer an introductory level transportation engineering course during the junior or senior year of study. The material coverage in this course varies widely between institutions based on the instructor's expertise and the availability of other technical elective courses offered in transportation engineering area. For many students this is the only transportation engineering course they will take in their undergraduate civil engineering degree. In this introductory course majority of the instructors focus on land transportation with special emphasize on traffic and transportation planning and design. The faculty members area of expertize also dictates the material coverage in this course to some extent. Most faculty members who teach this course have traffic and transportation planning as their area of expertise. There is an ongoing debate among faculty who is teaching the introductory transportation engineering course about what needed to be included in this course. Several workshops and conferences were held in the past to discuss and debate this issue.

After studying the course schedule and syllabus from different institutions, the author found that this course primarily covers the traffic and transportation planning aspects in majority of the civil engineering programs. While developing the course to teach at his institution, he included various aspects of land transportation designs such as geometric design, pavement design along with traffic planning in the course. A small lab component was also added along with a comprehensive design project. In this approach, even if this is the only transportation course a student takes while in school, they still get an overall design details about land transportation. This will not only benefit them in their professional practice, but will also help with their preparation for the fundamentals of engineering and professional engineer exams.

Within approximately forty two class periods, the main spectrum of land transportation needed to be covered. So the author designed the course with equal coverage to all three areas and taught the class in spring 2010. Based on the student feedback, a design project was also introduced when the course was taught again in spring 2011, and 2012. Student teams were asked to work on a design project that incorporated the concepts and design methods learnt from all three areas. The author feels that this helped the students to have a clear understanding about transportation engineering. This paper provides the details on the development of this course, syllabus, and the student feedback.

Introduction

Nearly all of the nation's 224 civil engineering programs have one or two required transportation courses as part of their undergraduate program (Turochy, 2006). For some civil engineering sub-disciplines, such as geotechnical, materials, structures, and hydraulics, a logical sequence of required prerequisite courses leads to the required courses. For other disciplines, such as transportation, the logic and sequence is less clear. A lack of clarity and connection with other sub-disciplines pose significant challenges for faculty, students, and practitioners in transportation engineering. It is likely that these challenges negatively impact the "pipeline" so commonly discussed when considering transportation workforce development (Young et al., 2011).

A study conducted by Turochy found that in about 78% of the civil engineering programs an introductory level transportation engineering course is required for the successful completion of the degree. Further research on the course syllabi identified key attributes in the structure and requirements of this class as taught in 30 universities across the United States during the spring 2009 term. The course syllabi review showed that in 27 (90%) of the courses, the course appears to be focused predominantly on the highway mode of travel. A review of course topics found that highway geometric design and transportation planning are addressed in at least 90% of these courses (Turochy, 2006; Turochy, 2009). It is important to note that course content is shaped by many factors including the relationship of this course to other courses in a particular institution's program, the setting and constituent groups of the institution, as well as the technical expertise of the course instructor. Introductory transportation course content taught at two different institutions may not be the same, nor should they be. Courses should be designed to reflect the expertise of the instructor and the interests of the students, while covering key learning outcomes for the profession. Content might also vary depending on the setting of the university (urban vs. rural) or how the introductory course fits in a sequence of transportation courses offered in a program (Kyte et al., 2010).

It is reported that an estimated 40 to 50 percent of the transportation workforce will be eligible to retire in the next 10 years (TRB, 2003). The civil engineering programs will play a critical role in developing the transportation workforce necessary by equipping them with the needed design knowledge. So while preparing this course, it is very important for the instructor to design the content in such a way that this course will cover all aspects of land transportation to prepare the students for success in follow-up courses, the professional workplace, and in graduate study. In this approach, even if this is the only transportation course a student takes while in school, they still get an overall design details about land transportation. This will not only benefit them in their professional practice, but will also help with their preparation for the fundamentals of engineering and professional engineer exams. After studying the course schedule and syllabus from different institutions, the author found that this course primarily covers the traffic and transportation planning aspects in majority of the civil engineering programs. While developing the course to teach at his institution, he included various aspects of land transportation designs such as geometric design, pavement design along with traffic planning in the course. More details about this course development are explained here in this paper.

Course Description and Details

The introductory transportation engineering course (CE 350 Transportation Engineering) is a three credit hour course. The catalog description of the course states the following: "Introduction to the activities of the transportation engineer, including aspects of physical design of facilities, as well as systems modeling and control with emphasis on land transportation". Surveying and Dynamics are the pre-requisite for this course. This class met three hours a week. The fourth edition of "Principles of Highway Engineering and Traffic Analysis" by Mannering, Washburn, and Kilareski was used as a text book.

There were nine students in the class when it was taught in Spring 2012 and twenty students in Spring 2011. Grades were assigned based on the performance in three exams, homework and the design project. A design project was assigned and the students were asked to follow the FHWA and INDOT guidelines for the project. The entire project was divided into manageable small design components and the students were asked submit the interim design which accounted for 40% of the project grade. It was made sure that the weekly submissions were in line with the material covered in the class for that week. The weekly design submissions were corrected and returned with feedback. This helped the students to make steady progress on the project rather than waiting to complete the entire design at the last minute. Industry professionals from the transportation industry were invited to give guest lecture in the class. The students also made a field visit to I-69 project site in Evansville, IN. Also the students attended the SuperPave binder testing demonstration followed by the visit to a paving plant.

The entire semester was divided into three components, namely geometric design, pavement design and traffic design. In geometric design the vehicle characteristics such as resistance, tractive effort, and braking along with other vehicle and road user characteristics were covered in detail followed by the vertical and horizontal curve design. The AASHTO green book (A Policy on the Geometric Design of Highways and Streets) was used to supplement the design concepts covered in the textbook. After the first exam the design project was introduced. The empirical pavement design concepts were taught including traffic projection, material selection and layer thickness design for both flexible and rigid pavements. The AASHTO Guide for Design of Pavement Structures was used to supplement the textbook. The Superpave testing protocol was also covered in a class. The last four weeks were used to cover traffic planning and design concepts such as traffic capacity, level of service, traffic stream parameters, traffic surveys, and traffic control. Even though many things can be covered in transportation the main emphasis was placed on covering the three main design elements (geometric, pavement and traffic) in this introductory level engineering course. In this approach, even if this is the only transportation course a student takes while in school, they still get an overall design details about land transportation. This will not only benefit them in their professional practice, but will also help with their preparation for the fundamentals of engineering and professional engineer exams.

Transportation Engineering Syllabus

The class syllabus is given in Table 1.

Table 1. Transportation Engineering Syllabus

Week	Class #	Topic
1	1	Course Introduction, Basics
	2	Road Vehicle Performance - Resistance
	3	Tractive Effort & Acceleration
2	4	No Class: MLK Holiday
	5	Principles of Braking
	6	Sight Distances
3	7	Design Problems: Sight Distance
	8	Geometric Design: Vertical Alignment
	9	Vertical Alignment
4	10	Vertical Alignment
	11	Horizontal Alignment Design
	12	Horizontal Alignment
5	13	Horizontal Alignment
	14	Design Problems on Alignments
	15	Exam 1
6	16	Pavement Basics
	17	Traffic Projection Techniques
	18	Traffic Projection for Design
7	19	Material Characterization
	20	Discussion on Design Inputs
	21	Guest Lecture
8	22	Flexible Pavement Design: AASHTO
	23	Flexible Pavement Design: AASHTO
	24	Site Visit - I 69 Project
9	25	Rigid Pavement Design: AASHTO
	26	Rigid Pavement Design: AASHTO
	27	Problem Solving in Pavement Design
10	28	SuperPave
	29	SuperPave Binder Testing Laboratory
	30	Site Visit - Paving Plant
11	31	Exam 2
	32	Traffic Planning and Design Introduction
	33	Traffic Stream Parameters and Models
12	34	Traffic Stream Parameters and Models
	35	Highway Capacity & LOS
	36	Highway Capacity & LOS
13	37	No Class: Easter Break
	38	Traffic Control
	39	Traffic Signal Phasing & Timing
14	40	Traffic Surveys: Spot Speed Study, Turning Movements
	41	O-D Study & Parking Analysis
	42	MUTCD

Student Feedback

This section has some of the student comments copied from their course evaluation feedback section.

"I enjoyed this class so much; it changed my future employment interests."

". ….I liked that the final project tied everything together. "

"The project was very helpful to learn the course material..."

"Going into this course I did not expect myself to learn as much as I did but this course was excellent. I learnt not only numerical principles but factual knowledge I never knew. I liked the course layout and the course field trip. I look at transportation engineering in a more appreciative way now."

"Project breakdown worked well."

"The project was good, broken into multiple submissions."

"I liked the way the project was broken up into smaller steps."

Conclusion

The last two years, this course was designed and taught to cover all aspects of land transportation to prepare the students for success in follow-up courses, the professional workplace, and professional licensure exams. Some of the active learning techniques and course content ideas from the recent NSF Transportation Engineering Educators Conference participation will also be considered in the course design in future. The positive feedbacks from the students indicate that the objective of this course to cover all three design aspects of land transportation was achieved successfully in the last two years.

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