AC 2009-274: EFFECTIVE USE OF THE HIGHWAY CAPACITY MANUAL AND SOFTWARE IN TEACHING PHYSICAL ELEMENTS OF TRANSPORTATION ENGINEERING

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Effective use of Highway Capacity Manual in Teaching Physical Elements of Transportation Engineering

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ABSTRACT

In this paper, the effective way of explaining concepts of design and analysis of physical elements of transportation engineering, such as signalized intersection, two-way multi-lane highway, two-stop control, all-way stop control, ramps, weaving lanes, roundabout using the Highway Capacity Manual and the software is explained. The instructor teaches this course every alternate spring semester to the seniors and graduate students as part of the advanced transportation elective. The instructor reinforces the concepts by requiring students to solve the problems in the Highway Capacity Manual and solving the same problems with highway capacity software. Then, as part of the homework, the students, in group of three, solve the problems manually and then follow-up with solving the problem with Highway Capacity software. After each topic is completed, a design project obtained from a local reputed consulting firm is assigned to each group. The students then make a short presentation of their design to the class (15-20 min) with the consultants from the firm serving as clients. This pedagogical technique adopted for each of the physical elements of transportation provides the necessary depth to enhance the understanding of the development of the design procedure. The graduate students have to do a presentation and a paper on contemporary topics and the student performance measurement metrics, the student assessment, and the course evaluations are presented to demonstrate the effectiveness of this technique.

Problem-Based-Learning (PBL)

As the label implies, problem-based learning is an educational approach where an ill-structured problem initiates learning. PBL is necessarily interdisciplinary: by addressing real-world problems, students are required to cross the traditional disciplinary boundaries in their quest to solve the problem. One of the primary features of Problem-Based Learning is that it is student-centered. "Student-centered" refers to learning opportunities that are relevant to the students, the goals of which are at least partly determined by the students themselves[1]. This does not mean that the teacher abdicates her authority for making judgments regarding what might be important for students to learn; rather, this feature places partial and explicit responsibility on the students' shoulders for their own learning. Creating assignments and activities that require student input presumably also increases the likelihood of students being motivated to learn.

A common criticism of student-centered learning is that students, as novices, cannot be expected to know what might be important for them to learn, especially in a subject to which they appear to have no prior exposure. The literature on novice-expert learning does not entirely dispute this assertion; rather, it does emphasize that our students come to us, not as the proverbial blank slates, but as individuals whose prior learning can greatly impact their current learning[2]. Often they have greater content and skill knowledge than we (and they) would expect. In any case, whether their prior learning is correct is not the issue. Whatever the state of their prior learning, it can both aid and hinder their attempts to learn new information. It is therefore imperative that instructors have some sense of what intellectual currency the students bring with them. The context for learning in PBL is highly context-specific. It serves to teach content by presenting the students with a real-world challenge similar to one they might encounter were they a practitioner of the discipline. Teaching content through skills is one of the primary distinguishing features of PBL. More commonly, instructors introduce students to teacher determined content via lecture and texts. After a specific amount of content is presented, students are tested on their understanding in a variety of ways. PBL, in contrast, is more inductive: students learn the content as they try to address a problem. The “problems” in PBL are typically in the form of “cases”, narratives of complex, real-world challenges common to the discipline being studied. There is no right or wrong answer; rather, there are reasonable solutions based on application of knowledge and skills deemed necessary to address the issue. The “solution” therefore is partly dependent on the acquisition and comprehension of facts, but also based on the ability to think critically. PBL, by having students demonstrate for themselves their capabilities, can increase students’ motivation to tackle problems. Three major complaints from employers about college graduates are graduate’s poor written and verbal skills, their inability to problem-solve, and their difficulties working collaboratively with other professionals. PBL can address all three areas. However, the pedagogical technique used in this study is a combination of both PBL and traditional lectures. The students are given the basic theory in class; however, the students understand the theory by solving real-world problems that are relevant to the theory.

Introduction

The advanced transportation engineering is taught in the senior year as an elective course for all civil engineering (CE) students. The course provides an in depth learning of various physical elements of transportation engineering. The course (Table 1) included six topics, 1) Simple signalized intersection; 2) two-way stop control; 3) all-way stop control; 4) multi-lane highway; 5) ramps and weaving; and 6) roundabouts. The class meets once a week for 150 minutes.

Table 1. Course outline

Week	Topic
1	Introduction/Background/Review
2	Signalized Intersection (SI) - Theory
3	
4	
5	SI - Highway Capacity Software (HCS)
6 (assign Take home Exam I)	
7	Two-Way Stop Corner (TWSC) - Theory
8	All-Way Stop Corner (AWSC) - Theory
9	AWSC - TWSC – Highway Capacity Software
10	Multi-lane highway (MLH) - Theory
11 (assign Take home Exam II)	MLH – Highway Capacity Software
12	Ramps and Weaving (RW) - Theory
13	RW – Highway Capacity Software
14	Roundabouts – Theory and HCS

Pedagogical Technique

In this paper, the author will explain the process used for one application, such as a signalized intersection design. The similar pedagogical methodology was utilized for other applications, such as All-way Stop Control Signalized Intersection and Two-Way Stop Control. Throughout this course, the author has extensively used the highway capacity manual not only as a design tool, but also as a way of to explain the theory behind the development of the design. The outline explained above reflects the methodology outlined below.

Signalized Intersection
A step-by-step framework of explaining signalized intersection is shown in Figure 1 below:

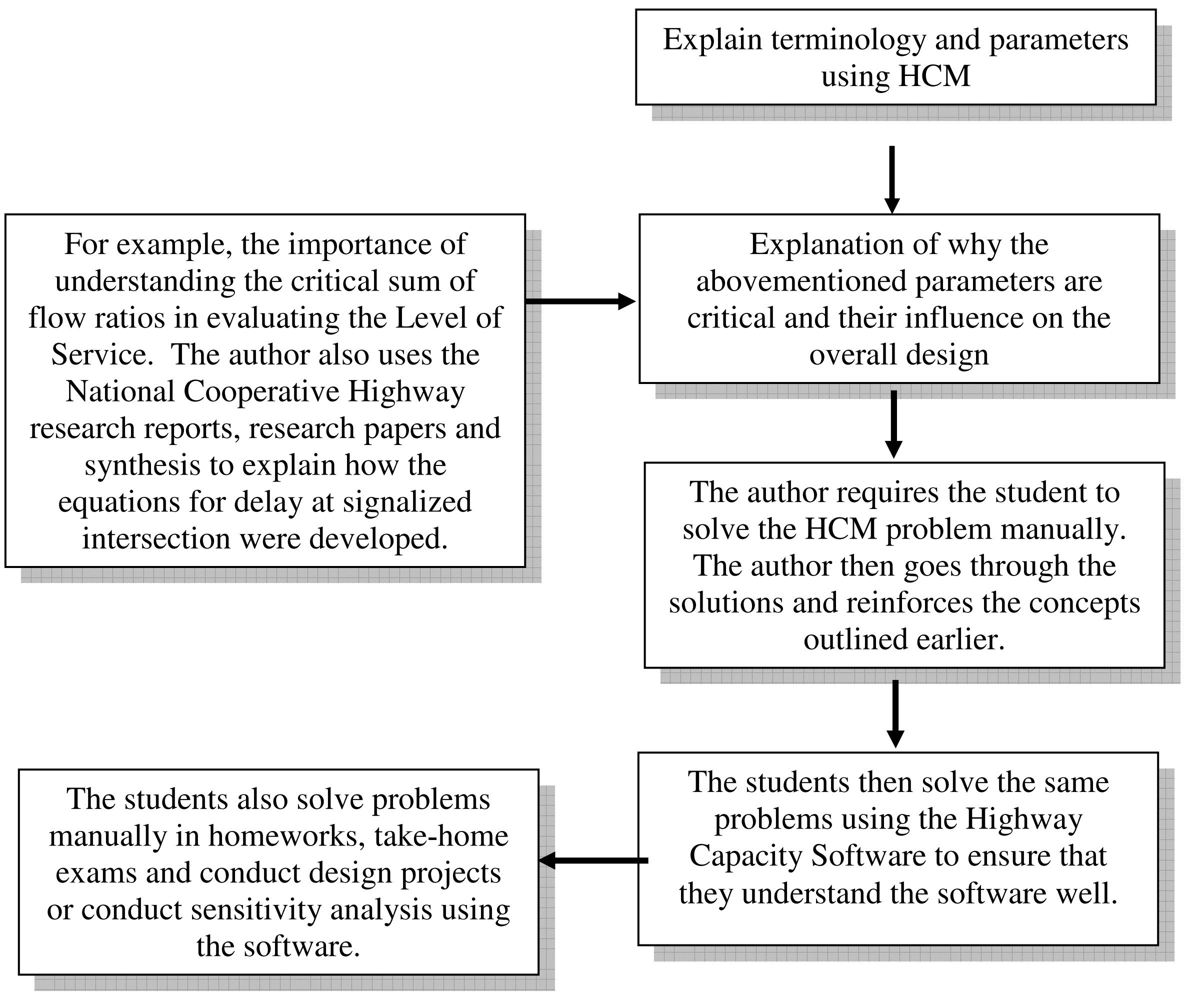

Figure 1. Pedagogical Technique Used in this Course

Impact of Technique

Highway Capacity Manual/Software is premier software utilized in the design of physical elements by most of the civil engineering firms. The user interface of the software is relatively simple; however the output may not make sense if the engine behind the software is not well understood. The above mentioned pedagogical technique required them to understand how the analysis works. Since, most of the delay models are empirical, it is essential to focus on understanding the parameters that are involved in the equation, the boundary conditions, and the basic concepts related to the development of the model.

Homework, Exams, Projects, Presentations, and Quizzes

The grading scheme for the course is summarized in Table 2. All homework and exams were take-home and team-based. The homework were to be submitted within a week and the exams to be submitted within 48 to 72 hours, in which the team-members could discuss their effort as they presented their solutions to complex analysis and design problems. The take-home exams allowed the instructor to push the students to conduct complex analysis of existing transportation applications manually and by using the software. The exam required them to refer to all available resources, beyond the textbook and the class notes to solve the problems. On the other hand, the quizzes were conceptual questions to be attempted by each student individually and it was closed book. The purpose of the quizzes was to evaluate if the students understand the concepts taught in the class. The quizzes were very short; it took students an average of 10 – 20 minutes to answer the questions. The students who understood the concepts have regularly performed well in the quizzes.

The projects involved conducting sensitivity analysis of various parameters, such as the Peak Hour Factor (PHF) or unit extension of green on intersection capacity. In addition, the instructor obtains data for design of various elements, such as Signalized Intersection from consulting firms in the region. The students present their design to the employees of the firm, who serve as consultants.

Table 2. Summary of grading scheme for course

Evaluation	Format	Turnaround	Weighting
Homework	Individual, take home	1 week	20 %
Quiz	Individual, closed book	In class	20 %
Project/presentation	Team- based	1- week	30 %
Midterm and Final exam	Team-based, take home	72 hours	30% (for both)

Student Evaluation

The instructor evaluation (Table 2) was very positive. The response to questions 3 (in bold), the 100% of the students clearly found that the technique stimulated thinking and 5 (in bold) clearly showed that a significant percentage of students (75 %) were actively engaged in teaching and learning. The comments (Table 3) clearly showed that the students perceived the class positively. The students found the class to be challenging and liked the teaching style.

Table 3. Student Evaluations

	Student Response Scores							
		Not Applicable	1	2	3	4	5	Avg
1	Was the professor responsive to students' needs, questions, and ideas?				1	2	12	4.73
2	Was the professor enthusiastic about the subject?						15	5.00
3	**Did the professor stimulate thinking?**						**15**	**5.00**
4	Did the professor require a high level of student performance?					4	11	4.73
5	**Did the professor actively involve students in teaching and learning?**					**4**	**11**	**4.73**
6	Were handouts and assignments helpful for understanding the subject?					6	14	4.70

Long Term Evaluation

Several students have pursued transportation engineering after graduation and have received favorable responses from the employers. This has been complemented by the employers seeking our students for employment in transportation engineering in subsequent years. The instructor has not conducted a formal evaluation of student learning before and after the proposed technique study was implemented. Therefore a formal evaluation of the proposed technique is unavailable. Even though this is based on a single observation, the author believes it is still valuable to disseminate the technique.

Table 4. Student Comments

No	Comments
1.	Dr. Mehta is the best professor I have ever had and he has inspired me to continue with transportation engineering (by working @the DOT). Dr. Mehta, you are awesome!!
2.	He's the best!
3.	Dr. Mehta is by far one of the best, if not the best teacher Rowan has to offer. He listens to the students while making learning fun. Dr. Mehta has shown me the path that I will be taking into the future.

Conclusions

Based on the five different courses during the past seven years the authors has tried innovative teaching techniques in a wide range of classes such as pavement materials[1], surveying and engineering graphics[2], civil engineering materials[3] and dynamics[4]. The author strongly believes that the new technique is beneficial for both the instructor and the students. The methodology has been very effective; the students are very involved in the learning process and many have successfully pursued career in transportation engineering. The author strongly believes that teaching is a learning process for the faculty. The author is continuously evolving and improvising the technique to ensure that the students stay current with the latest developments and have a fruitful learning environment.

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