EFFECTIVE TEACHING IN TRANSPORTATION ENGINEERING: AN OVERVIEW AND APPLICATIONS

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ABSTRACT

Transportation professionals are facing complicated problems to address, which poses challenges for transportation education. This paper aims to understand what has been learned in transportation education to improve the teaching strategies of transportation educators. In particular, the following aspects have been examined: curriculum design, effective teaching strategies, assessment of learning, and evaluation of teaching. A before and after analysis based on the authors' four years teaching in an undergraduate core subject has been conducted to demonstrate the effectiveness of the proposed methodology. In this paper, we intend to share our experiences in helping to train more qualified transportation professionals that could address the complicated transportation problems in the society.

Keywords: Transportation pedagogy; engineering education; effective teaching

1. INTRODUCTION

In the latter part of the 20th century, transportation engineering became a discipline in its own. Transportation education is an independent engineering program as well as support for other academic disciplines, such as defense, energy, environment, and urban planning. The practice of transportation engineering has evolved considerably with the increase of car ownership in the world. Transportation professionals are facing complicated problems to address, such as growing congestion, environmental pollution, sustainability of energy, and social equity (Zhou and Schweitzer, 2009). The learning objective of transportation courses is to equip the future transportation professionals with necessary knowledge, problem-solving capabilities, scientific and systematic way of thinking, and other skills such as presentation for addressing practical transportation problems.

Transportation educators have been striving to improve teaching quality by designing, implementing, and evaluating various teaching strategies. The purpose of this paper is to summarize the literature on transportation education to understand what has been learned in this area so as to improve the teaching strategies of transportation educators. Some of the effective teaching strategies in transportation can also be applied to other disciplines and effective teaching strategies in other disciplines may also be applicable to transportation engineering. Nevertheless, in this paper we confine the topic to the teaching of transporting engineering subjects, as disciplines have their own way of thinking and practicing (Land, 2013).

The remainder of this paper is organized as follows: Section 2 discusses curriculum design. Section 3 reviews effective teaching strategies in the literature. Section 4 is devoted to the review of assessment of learning. Section 5 discusses the evaluation of teaching. The last section concludes.

2. CURRICULUM DESIGN

The advancement of knowledge and ever-changing environment are the reasons for revising existing curricula, canceling a subject, and launching a new subject. Balsas (2001) found that in traditional transportation curricula, the importance of bicycle and pedestrian planning had been underestimated. He conducted surveys and concluded that there had been little progress in educating future transportation professionals with regard to cyclists and pedestrian. Consequently, he designed the subject and taught in his own university. Krizek and Levinson (2005) analyzed syllabi from 15 courses in North American transportation planning programs by comparing the numbers of lecture hours and the contents. They noted that it is difficult to consider the content of a course without considering other related courses because some contents that are not covered by the course may be included in other courses. In sum, curriculum design is the foundation of effective teaching and in curriculum design one should bear in mind the core elements including learning outcomes, teaching activities, learning activities, learning resources, feedback activities, assessment tasks, and grading standards (Angelo, 2013).

3. EFFECTIVE TEACHING STRATEGIES

A number of effective teaching strategies have been discussed in the literature on transportation education. These strategies have been proved to be successful in terms of the learning outcomes. It should be mentioned that the strategies are not only applicable to transportation education, but also to the pedagogy of other disciplines.

3.1 Guest lecturers

Balsas (2001) mentioned that inviting guest lecturers, including those within the department and outside practitioners, added value to his class on bicycle and pedestrian planning. This is true for many engineering subjects as different lecturers could bring in different expertise. Guest lecturers from the industry could further teach the most up-to-date practice in real applications. A rule of thumb for choosing guest lecturers is that they should have expertise complementary to the regular lecturers.

3.2 Computer simulation

Computer simulation has been widely applied to assist teaching transportation engineering students. On one hand, it allows practicing new skills in a risk-free environment. On the other hand, it enables interactions between computer programs and learners and could provide immediate feedback. As a result, a large amount of research has been devoted to the application of computer simulation to transportation education, for example, Chen and Levinson (2006), King et al. (2008), Liao et al. (2009; 2010), Pande and Grimes (2011), Zhu et al. (2011), Brown et al. (2013), and Liao and Levinson (2013). In particular, Zhu et al. (2011) applied an agent-based demand and assignment model (ADAM) to teach traffic equilibrium. The motivation is that the traffic equilibrium concept may be too abstract for students with little background in optimization. Brown et al. (2013) used mobile signal time training (MOST) for dynamic traffic animation, as students had misconceptions in traffic signal control from their experience of driving, and computer simulation helped them build the correct concepts.

It should be noted that it is difficult to develop computer simulation packages without substantial funding support. Consequently, a practical approach for situations with no or little funding support is to search free packages online and use them in class.

3.3 Games

Games are fun and could stimulate learning. In contrast to simulation which aims to finish a task, the purpose of a game is to win. As a result, the interaction between one player and the others (i.e., trying to defeat the other players) makes the process more exciting. Huang and Levinson (2012) employed board games for transportation engineering education, in which each student played a role, such as a railway company, a banker and a factory, and aimed to earn as much as possible by interacting with other players and under the uncertain economic environment. Students were highly focused and excited in the games and the learning outcomes were excellent.

Designing a board game does not require much funding. Nevertheless, the experience of Huang and Levinson (2012) demonstrated that it is possible that a large proportion of the time is spent in understanding the rules for the games.

3.4 Problem-based learning

Problem-based learning is based on principles including acknowledging the prior knowledge and experience that learners bring to the learning environment, providing real-life applications, and developing active and self-motivated learners (Brodie, 2013).

Alvarstein and Johannesen (2001) designed problem-based teaching approaches for lower level transportation subjects. In such approaches, students form groups and each group works on a realistic problem. Students need to learn the knowledge required to solve the problem themselves. The advantage of problem-based approaches is that they create motivation, study activity, context with reality and a social atmosphere for learning.

3.5 Field work

Obadat (2007) implemented transportation field studies, one of which is measuring the speeds of cars at a spot. Students need to measure the speeds of many cars, draw the distribution of the speeds and analyze the results. Through such field works, students are more familiar with standard procedures and standard forms, data analysis, field work, group work and professional software implementation.

Many preparations are necessary before conducting the field works. Prior to field work, the aim and procedure of the field work must be elaborated. Equipment for field work has to be available. Transport to and from the field must be arranged, and safety at the field must be guaranteed through a risk management scheme.

4. ASSESSMENT OF LEARNING

Assessment is not only a measurement of the outcomes of learning, but also an integral part of the process of learning (Brown and Race, 2003). There are many assessment techniques, such as assignments, reports, tests, exams and presentations. Nevertheless, not much transportation education literature is dedicated to assessment. We conjecture that this is because the assessment of learning in transportation does not have much difference with other disciplines (a comprehensive overview of assessment can be found in Black and Wiliam, 1998). At the same time, we did find the approach of interview for assessment might be enlightening as follows.

Brown et al. (2013) conducted pre-interviews and post-interviews to assess students' understanding of traffic signal control, i.e., face-to-face questioning and answering between the teacher and students. The advantage of interview lies in that it is interactive and any unclear or incomplete feedback from students could be clarified or completed by further questions. Interviews could also address the

problem of students' misunderstanding of the questions and teachers' misunderstanding of the answers. The problem with interview is that it is suitable for small classes only; otherwise it is too time-consuming.

5. EVALUATION OF TEACHING

A natural question in transportation pedagogy is: how to evaluate the effectiveness of teaching? Based on the literature, we found the following methods: formal teacher evaluation, student survey, comparison between different teaching strategies, and follow-up investigation of how many students pursue transportation profession.

5.1 Formal teacher evaluation

Balsas (2001) used the teacher evaluation as an indicator of whether his new subject on bicycle and pedestrian planning is a success or not. In general, the fact that students felt excited in the subject and felt that a lot had been learned is an indicator of success. Alvarstein and Johannesen (2001) applied both mid-term evaluation and final evaluation to seek students' opinion of the contents of a problem-based course. Most students found the content of the course interesting. In sum, students' subjective impression of a course could be used as an indicator.

5.2 Survey

In contrast to teacher evaluation which requests students to evaluate the teacher and the course, in a survey students are asked to evaluate their own learning outcomes.

Huang and Levinson (2012) conducted pregame survey and postgame survey to evaluate whether the goal of the game helping students to understand the interactions of stakeholders and the economic principles is achieved. Questions in the pregame survey, which aims to evaluate the effect of games on different types of students, are mainly on the demographics of the students. Questions in the postgame survey could be, for example, "to what extent has the game improved your understanding of network deployment"? Students' response could reflect whether they have gained a deeper understanding or not.

5.3 Comparison

It is impossible to divide students into two groups, one group using conventional teaching techniques, and the other group employing new techniques, for comparison of different approaches. This is because such a division may be perceived as unfair. Possible approaches are to compare the results of students with other subjects, or to use different teaching techniques in different semesters (or in the same semester but at different institutions).

Alvarstein and Johannesen (2001) compared the average grades of their class with problem-based study approaches with the grades of these students in other subjects. The fact that more than half of the students obtained better grades in the problem-based class demonstrated the effectiveness of the problem-based approaches. Of course, this conclusion is subject to the criticism that maybe the grading was too generous.

Zhu et al. (2011) compared the survey results (not grade) of students from two semesters (using different teaching approaches: computer simulation and conventional approaches), and the students from the semester using computer simulation techniques felt that deeper understanding had been gained and more skills had been obtained. This comparison demonstrated the effectiveness of the

computer simulation techniques.

5.4 Retention

Liao et al. (2010) argued that one goal of simulation modules in transportation education is to encourage highly motivated students into transportation profession. Therefore, relevant indicators include: do student taking the simulation modules thereafter take more transportation courses? Do these students become transportation engineers?

6. CONCLUSION

Transportation professionals are facing complicated problems to address, which poses challenges for transportation education. This paper aims to understand what has been learned in transportation education to improve the teaching strategies of transportation educators. In particular, the following aspects have been examined: curriculum design, effective teaching strategies, assessment of learning, and evaluation of teaching. A before and after analysis based on the authors' four years teaching in an undergraduate core subject has been conducted to demonstrate the effectiveness of the proposed methodology. In this paper, we intend to share our experiences in helping to train more qualified transportation professionals that could address the complicated transportation problems in the society.

7. ACKNOWLEDGMENT

This study is supported by the first-stage projects of course development in Jiangsu universities (Transportation Engineering), No. PPZY2015B148.

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