Inclusive Learning Approach to Teach Concepts of Pavement Management Systems to Seniors and Graduate Students in Civil Engineering

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Inclusive Learning Approach to Teach Concepts of Pavement Management Systems for Senior-Year Undergraduate and Graduates Students

Abstract

The goal of this paper is to disseminate an enhanced methodology and strategy to college instructors that can be successfully employed in a data-driven, project based course like Pavement Management Systems (PMS). PMS is a course offered in the Department of Civil Engineering at Rowan University's College of Engineering. The objective of the course was to provide a thorough understanding of the pavement management process and demonstrate how concepts of life cycle cost analysis are utilized in the decision making process. The course required students to utilize state of the art approaches that are typically employed by transportation agencies to analyze pavement performance data at the project and network levels. The PMS course was offered as an elective course dedicated to senior-year, undergraduate students as well as graduate students (i.e., Masters and Doctoral students) in Civil Engineering; whose academic interests lie within the field of transportation engineering. Lectures were conducted with the aid of multimedia presentations and students were often asked to form groups of two and participate in classroom assignments. The classroom assignments typically focused on material covered and incorporated authentic PMS scenarios and actual pavement performance data. In the second half of the course, undergraduate students were required to form groups of 3 and develop a data-driven, research, project that compared PMS used in the United States to those used in a developed and developing country. Graduate students were required to form groups of two, and formulate a research project using pavement performance data from the Federal Highway Administration's Long-Term Pavement Performance (LTPP) database. All groups were then asked to present weekly updates of their respective research projects to the class in order to receive feedback from their peers and instructors. Based on the feedback from student evaluations of the class project and overall PMS course, 77% of students agreed that the class project helped them to learn about pavement rehabilitation strategies and performance models and 64% of students agreed with the format of the weekly project presentations. Undergraduate students gave the teaching style and format of the course an overall average score of 3.94 out of 5 while the overall average score for graduate students was 4.64 out of 5.

Introduction

Over the last few decades, the use of transportation infrastructure has continued to increase in many developed and developing countries due to population growth and economic expansion. This escalating use of transportation infrastructure; coupled with financial constraints, has forced transportation agencies to shift more attention on the preservation and maintenance of existing infrastructure (i.e., pavements) rather than the construction of new highways [1]. For example, the United States Department of Transportation (USDOT) invested $91 billion in 2013 for the purpose of pavement maintenance to restore the road network to a satisfactory, operational condition [2]. The main objective of any federal, state or municipal transportation agencies is to develop an efficient system of planning for the maintenance, rehabilitation, and construction of roadway networks; within the confines of allocated funding. Most transportation agencies utilize a pavement management system (PMS) to achieve this objective.

A PMS is defined as an organized approach that incorporates the use of decision making tools to aid agencies in selecting the most cost effective maintenance scheme for a road network [3]. A PMS typically requires continuous measurement of pavement distress data, development of accurate models to predict pavement condition (based on measured distresses), and the application of cost analyses to determine which combination of maintenance alternatives to apply. Due to the multifaceted nature of PMS and the overall emergence of PMS in the transportation engineering industry in recent time, it was determined that Civil Engineering students at Rowan University should be exposed to the concepts of PMS. This exposure to PMS was considered to be vital for students because it would allow them to better adjust to the demands of transportation engineering; post-graduation.

As such, a newly developed, Pavement Management System course was offered in the Department of Civil Engineering at Rowan University's College of Engineering. The course was structured in a way that afforded students the opportunity to apply the knowledge gained about PMS to both a familiar, domestic setting and a global setting. This course structure was utilized to facilitate the requirements of a grant awarded by The National Science Foundation (NSF) to the Civil and Environmental Engineering Department at Rowan University which, was geared towards increasing retention of inclusive curriculum reform. This paper will demonstrate the benefits of teaching pavement rehabilitation concepts from a global perspective and exhibit how that approach provided a technical basis for an inclusive learning experience.

Course Summary

The Pavement Management System course offered was an elective course dedicated to senior-year, undergraduate students as well as graduate students (i.e., Masters and Doctoral students) in Civil Engineering; whose academic interests lie within the field of transportation engineering. The PMS class consisted of 17 full-time, undergraduate students and 9 graduate students; two of which were part time. Two of the graduate students were Doctoral students and 7 were Master of Science students. The objective of the PMS course was to provide a thorough understanding of the pavement management process and demonstrate how concepts of life cycle cost analysis are utilized in decision making processes. An outline of the PMS course is presented in Table 1. It can be observed from this table that the course spanned over 16 weeks and covered a broad range of topics. These topics included: 1) the assessment of pavement condition, 2) measurement of pavement quality, 3) evaluation of pavement structural capacity, and 4) selection of pavement maintenance and rehabilitation alternatives based on measured performance data (i.e., pavement preservation strategies). The course required students to utilize state of the art approaches that are typically employed by transportation agencies to analyze pavement performance data at the project and network levels. The primary textbook utilized for the course was, "Pavement Asset Management," [4]. A free supplementary electronic textbook entitled: "Modern Pavement Management," [5] was also made available through Rowan University's library specifically for the PMS course.

The course was taught using a combination of three main teaching styles: the demonstrator, facilitator, and delegator teaching styles. Lectures were conducted with the aid of multimedia presentations and students were often asked to form groups of 2 and participate in classroom assignments. The classroom assignments typically focused on material covered and incorporated authentic PMS scenarios and actual pavement performance data. In the second half of the course, students were exposed to principles of inclusive learning. Undergraduate students were required

to form groups of 3 and develop a data-driven, research, project that compared PMS used in the United States to those used in a developed and developing country. Graduate students were required to form groups of 2, and formulate a research project using pavement performance data from the Federal Highway Administration's Long-Term Pavement Performance (LTPP) database. All groups were then asked to present weekly updates of their respective research projects to the class in order to receive feedback from their peers and instructor. A disaggregation of the grading system utilized for the PMS course is presented in Table 2. From this table, it can be observed that the project accounted for approximately 20% and 30% of the final grade for undergraduate and graduate students, respectively. The grading system placed emphasis on the project to ensure student participation and motivate students to make a diligent effort on their respective projects. The average grade of the undergraduate students was 88% while the average grade of all graduate students was 92%.

Table 1. Outline of Pavement Management Systems Course

Week	Proposed Topics
1	Introduction – Evolution of pavement management systems
2	Data requirements – Surface distress condition surveys and structural capacity (Falling Weight Deflectometer)
3	
4	Determining present and future needs – Programming of rehabilitation and maintenance alternatives, pavement condition index (PCI), prediction models
5	
6	Structural design and analysis – Traffic, Asphalt institute method and AASHTO Design for flexible pavement, back calculation of pavement layers moduli using BAKFAA, MEPDG practices
7	
8	
9	Midterm Exam
10	Economic evaluation and analysis – Role of maintenance, key components of implementation of pavement management in construction, Research management
11	
12	
13	Cost and benefit of pavement management
14	New and emerging technology for pavement rehabilitation
15	Future needs for innovation in pavement management
16	Final Exam/Presentations

Table 2. Grading System Used for PMS Course

Assignment Category	Grading Weight (%)	
	Undergraduate	Graduate
In-class problems	15	10
Mid-term exam	20	20
Final exam (comprehensive)	20	20
Homework	15	10
Quizzes	10	10
Project	20	30

In-class problems

Toward the end of the every class, students were assigned in-class problems based on the concepts covered during the lecture. They were given the option to work on the problems

individually or in teams of two. The purpose of the in-class examples was to reinforce the PMS concepts covered during the lectures and to allow students to apply the knowledge gained to realistic situations. The in-class problems were typically assigned in-lieu of example problems the instructor would solve using a traditional teaching method. That is, the instructor would usually dictate and demonstrate the detailed steps that should be used to solve the problem presented in the example. However, the instructor would often engage students during computational steps to ensure that they understood the process being used to solve the example problem. Before the class was dismissed, the students were required to submit their solutions to the in-class problems. The instructor graded in-class problems based on accuracy of the answer provided and the problem-solving process used. The solutions to the in-class problems would then be presented to the class before the start of the next lecture.

The in-class problems proved to be a useful teaching practice and supplementary learning strategy for the students. The in-class problems forced the students to discuss and share ideas about using field-collected performance data to evaluate pavement condition; while the PMS concepts were fresh in their minds. This pedagogical technique is not novel or unique because it has been adopted in many classroom settings. However, in this particular case, this technique was essential and truly valuable because it allowed students to understand the applications of the pavement management and rehabilitation practices taught and allowed them to appreciate the meaningfulness of these practices. The instructor conducted the lecture for 1.5 to 2 hours, and allotted 1.5 to 1 hour for in-class problems and quizzes during the first four weeks of the course. However during the last four weeks of the course, students were required to present weekly, project updates to the class with the aid of multi-media presentations. The same time that was allotted for in-class problems were allocated to these weekly, presentations.

Class Projects

For the class projects, the 17 undergraduate students were divided into five groups. Two groups consisted of 4 students and 3 groups contained 3 students. The students were involuntarily assigned to groups by the instructor based on their cumulative grade point average (GPA). In order to form the groups, the instructor ranked the students based on their respective GPA and separated the class into three overall categories (high, medium, and low GPA). Each project group was assigned a student from the high, medium, and low GPA category, respectively. This task of assigning students to specific project groups was carried-out to ensure that there was parity among the project groups. The undergraduate student groups were then allowed to select their project topic from a list of predefined PMS related topics. These topics included the following:

- Airport pavement management and rehabilitation
- Preservation of highway pavements and pavement service-life cost analysis
- Innovative pavement health monitoring methodologies
- Cold-region asphalt and concrete pavement management and rehabilitation
- Pavement failures, distresses and their causes

The objective of the project for the undergraduate student groups was to present a detailed summary of findings and compare the implementation of their PMS related topic in the

US, to that of a developed country, and developing country. At the end of the semester each group was assessed based on a 20 minute, in-class, multimedia presentation. This project was intentionally designed as a means of promoting diversity and global engineering inclusivity.

With respect to the graduate student project, the Doctoral and Master of Science students were asked to voluntarily divide themselves into four groups. Three graduate student groups consisted of 2 students and 1 group consisted of 3 students. The graduate students were asked to formulate a data-driven, research project using pavement performance data from the Federal Highway Administration's Long-Term Pavement Performance (LTPP) database under the following predefined topics:

- Impact of climatic regions on the condition of asphalt pavements on a bound base
- Influence of recycled asphalt pavement (RAP) on the performance of flexible pavements with granular base
- Effect of resilient modulus of subgrade soil and modulus of granular base on the performance of asphalt overlays (i.e. composite pavement sections)
- Performance evaluation of composite overlays under the influence of different climatic conditions and traffic volume.

The graduate students were required to finalize the scope and depth of the projects with the instructor. The graduate students were also strongly encouraged to discuss the scope of their project with their respective academic advisor to evaluate whether results from the project or PMS concepts learned in this class could be adopted in their graduate research work. At the end of the semester, each group was assessed based on a 20 minute, in-class, multimedia presentation. Each groups also was required to prepare a detailed final report of their results and findings.

Both undergraduate and graduate student groups were required to present progress updates to the entire class every week for 5 to 10 minutes. The undergraduate student groups discussed the pavement maintenance strategies, challenges and successes of PMS in the US and selected countries, as well as the results collected (to date) for their comparison. The graduate student groups presented the data collected (to date) as well as the analyses they performed during the each week. From the weekly presentations, the comparisons and analysis methodologies of the groups were refined according to the overall objectives of their respective projects. This refinement was based on feedback from student peers and the instructor.

On the final day of the course, all groups presented their projects to the entire class using multimedia, visual aids. This was done to facilitate open discussion of all the projects so that all students could realize the benefits of applying pavement management concepts to a broad range of field applications. The instructor used project-assessment surveys to assess the overall effectiveness of the class projects in enhancing student comprehension of PMS concepts.

Results of Independent Student Project Evaluation

This section presents the results of the independent project assessment surveys completed by both undergraduate and graduate students that were members of the PMS class. The anonymous survey consisted of two statements which, were related to the efficacy of the class

projects and the overall format of the class project. Student respondents were required to indicate whether they strongly agreed, agreed, were neutral, or disagreed with the statements. The results of the survey is presented in Table 3. Approximately 22 of a possible 26 students responded to the survey. Seventy seven percent of the student respondents either agreed or strongly agreed that the class project helped them to learn about pavement rehabilitation strategies and performance models. Sixty four percent of the student respondents indicated that the structure of the weekly project presentations was useful.

Table 3. Student Responses to Project Assessment Survey

Response	**Number of Respondents**	
	Statement 1: "The class projects help me learn about pavement rehabilitation strategies and performance models"	**Statement 2: "The structure of the project presentation on a weekly basis was useful"**
Disagree	1	2
Neutral	4	6
Agree	11	5
Strongly Agree	6	9
Total	22	22

In the survey, the students were asked to provide a reason for their responses in order to gain greater insight about the effectiveness of the class project. Students were also asked to respond to a series of questions that ranged from their knowledge about general pavement regulations and PMS regulations, the effectiveness of the class project, and major engineering insights gained from the project. The summary of the student responses to these questions are presented below.

Question 1: What do you know about regulations for pavement design such as the ones set by the American Association of State Highway and Transportation Officials, Federal Highway Administration or other national agencies?

Summary of Student Responses to Question 1:

Based on the discussion in class, as a transportation engineer, the students learned about the federal and state pavement standards, pavement design methods- Asphalt Institute and AASHTO, regulations for minimum pavement thickness requirements, empirical relationships of resilient modulus (M_R) used in design methods for testing and rehabilitation of cost-effective pavements and AASHTO and ASTM standards for pavement materials. Few students also cited that they were aware of decent amount of these standards from their material laboratories, class projects and other clinical research activities which provided promising environment of learning this class. The students also grasped that the pavement design is an iterative process that is often controlled more by cost efficiency than the need to get the longest service life out of a pavement section as funding is partly based on local and federal transportation agencies. They also gained deep understanding of the mechanistic-empirical method, traffic load (ESALs), truck traffic count (AADTT) and the stiffness of the different layers of pavements such as the asphalt layer, base layer, sub-base, and sub-grade layers. However, the students felt that they could be exposed to more common regulations and standards that they would use in the workplace.

Question 2: What do you know about regulations for pavement maintenance and rehabilitation techniques such as the ones set by the American Association of State Highway and Transportation Officials, Federal Highway Administration or other national agencies?

Summary of Student Responses to Question 2:

Over the course, the students acquired a knowledge of several maintenance and rehabilitation techniques which include crack seals, patching, microsurfacing, and Hot Mix Asphalt (HMA) overlays. They also gained knowhow about the AASHTO and FHWA standards for management and maintenance techniques and about ASTM (e.g. D4633) standards to calculate structural and surface indices such as pavement condition (or serviceability) index (PCI or PSI) which would be utilize to determine levels and criteria at which pavement maintenance and rehabilitation should be used. The students achieved the zest of these indices by determining the combination of various distresses based on the prevalence to their respective regions and roadways. The students also explored their software analysis skill by performing BAKFAA program which provided them understanding of backcalculation of pavement layers' stiffness.

Question 3: What are your thoughts on importance of weekly presentations for this PMS course?

Summary of student responses to question 3:

Most of the students observed that for feedback and questions on the presentations, the weekly progress presentations helped them keep the understanding of the project in depth and maintaining the high standards throughout the semester. The students also sensed that it was very resourceful for them to get a chance to ask questions without experiencing difficulties and getting stuck on a data analysis or a cluster (e.g. LTPP, MICA) and to get more motivated hearing where others were and also to get tips from others which would guide them with the correct path. However, few undergrad students perceived that the mid semester or biweekly progress presentations were good to keep them on track in lieu of the weekly presentations which made it bit stringent for them to keep up with other projects, research, and assignments of other obligations.

Question 4: What do you think will be the major engineering insights from your experience in this class project?

Summary of Student Responses to Question 4:

Intense and thorough instructions of this pavement class provided students to think beyond the bounds of current maintenance and rehabilitation techniques. The students experienced significant increase in their ability to make cost-effective assessment of pavement conditions such as mechanics behind pavement maintenance and rehabilitation, rehabilitation type, the correct time to perform rehabilitation and having engineering background knowledge on condition indices (PCI or PSI).The students also acquaintance with the major engineering insights which involved rigorous use of LTPP database, competency with pavement design methods, identify pavement failures to decide relevant rehabilitation method, employ truck traffic data (AADTT) and traffic load (ESALs), analysis of collected distresses. The students sometimes also struggled to interpret the available data due to the accuracy of the collected data.

Few graduate students developed an understanding on LTPP database citing that complete dataset was not available for certain pavement sections to support the analysis which comprised the various distresses to evaluate the conditions of specific pavements.

Based on the review of the student responses the overall sentiment was that the students generally liked the format of weekly project presentation updates. This is because the weekly updates provided them with an overall structure for their projects. The students also appreciated the weekly presentations because they were able to obtain constructive feedback from their peers and the instructor. The instructor also noticed that student peers generally expressed enthusiasm and engaged in lively discussions related to the objectives, scope, results, and analysis of the different projects. Groups often modified their pavement condition assessment (or rehabilitation) models or LTPP analysis methodology based on the feedback from in class discussions. A shortcoming of the class project was the open-ended nature of the project. Some students enjoyed the flexibility while other students became frustrated and would have preferred more structure in the project definition. Additionally, some students struggled with the data analysis and needed more guidance. Students also complained that four weeks was not sufficient time to complete a time-consuming, data-driven project. However, in some cases, these complaints were related to lack of student preparation and time-management. Anecdotal evidence of this occurrence was more common in the undergraduate student groups as opposed to the graduate student groups.

Results of Student Course Evaluation

This section presents the results of the student course evaluation surveys completed by both undergraduate and graduate students that were members of the PMS class. The course evaluations were conducted through a pre-established, university-wide online teaching evaluation system. The anonymous survey consisted of 12 questions which ranged from topics related to the instructor's teaching style, instructor feedback, instructor preparation, and student engagement. Student respondents were required indicate whether the instructor practiced specific actions, "Always," "Very often," "Sometimes," "Rarely," or "Never". The most favorable, numerical score of 5 was given to responses indicating, "Always," and least favorable score of 1 was given to responses indicating, "Never." An average score out of 5 was computed based on the responses to each question. An overall average score for the course was then computed based on the computed average score for each question.

The results of the undergraduate and graduate student course evaluations are presented in Tables 4 and 5 respectively. The results of the course evaluations for undergraduate and graduate students were analyzed separately to determine the overall effectiveness of combining undergraduate students with graduate students in a PMS course. Eleven of a possible 17 students responded to the survey while 8 of a possible 9 graduate students responded to the survey. An overall course evaluation score of 3.94 out of a possible 5 was given by the undergraduate students. The instructor's treatment of students (i.e., respect) received the highest rating with a score of 4.73 and the instructor's openness to student feedback received the lowest rating with an average score of 3.40. An overall course evaluation score of 4.64 out of a possible 5 was given by the graduate students. The instructor's active student engagement and ability to allow students to express opinions received the highest rating with an average score of 4.88. The instructor's ability to provide useful feedback was given the lowest rating with an average score of 4.25.

Generally the overall ratings of the course evaluations for both undergraduate and graduate students were good. This indicated that the teaching style of the instructor and overall format of the class allowed both undergraduate and graduate level students to better understand the PMS concepts taught. However, based on the individual average scores of the questions, it is clear that some improvement should be made in regard to providing students with more useful feedback about projects and assignments. Going forward, some adjustment should also be made in terms of allowing students to provide more feedback about the course throughout the semester.

Students were also asked to make general comments about the PMS course and its format in the online teaching evaluation survey. The general comments made by undergraduate student respondents and graduate student respondents are presented below in separate sections.

General Comments from Undergraduate Students about the Course
For the majority of the students, the class was intense but very informative and some of the topics were taught very well such as economic evaluations, serviceability indices and backcalculation of pavement layers. After internal mid semester feedback, the instructor executed students' concerns about keeping a lecture short at a time, though most of the students followed the teaching style of the instructor. Very few students suggested to record a lecture to watch it later to revise the subject matter before the tests.

General Comments from Graduate Students about the Course
The graduate students recognized that this class was very useful for the understanding of pavement management system as the instructor provided good applied research examples. Specially, the doctoral students found it very explanatory and interactive for pavement background as well as how to utilize the topics discussed in class to their respective research.

Question 5: What are your thoughts on the course outline and pattern of this pavement maintenance and rehabilitation class?

Summary of Student Responses to question 5:
The students gained at most insight of this class. The course outline was structured in a way that it was beneficial of learning the basic components and properties of the pavement design, rehabilitation techniques, economic evaluation, how to prevent maintenance, how to deal with distresses and how to fix them along with cost. The in class and homework problems were helpful in understanding the concepts learned in class and the general applications of the concepts learned in class and used in the field. The presentation of the material in each class was executed well, however in the future cohesion between concepts could use improvement. It was a really good introduction to everything so that students can understand things better in a real life situation. This class provided a good breakdown of different theoretical information, and skills using different software. In this class, the students also learned about pavement materials and how their performance and maintenance compares with traditional road surfaces. Also the part of class with international standards comparison was good except for that Rowan/interlibrary loan that doesn't subscribe to many international standards. Overall course content was informative and useful.

Table 4. Undergraduate Student Course Evaluations

Question	Number of Student Response					
	Always (Score: 5)	**Very Often (Score: 4)**	**Sometimes (Score: 3)**	**Rarely (Score: 2)**	**Never (Score: 1)**	**Average (out of 5)**
The instructor taught the subject in way it was easy to learn?	3	1	6	1	0	3.55
Instructor gave clear explanations	2	3	6	0	0	3.64
Instructor asked questions to promote thinking	6	3	2	0	0	4.36
Instructor addressed student questions and comments	5	3	3	0	0	4.18
Instructor provided useful feedback to students	1	4	5	1	0	3.45
Instructor treated student with respect	9	1	1	0	0	4.73
Instructor actively engaged student	5	4	2	0	0	4.27
Instructor engaged students to express ideas or opinions	4	4	3	0	0	4.09
Instructor was prepared for class	5	3	3	0	0	4.18
The instructor communicated course and lesson goals	3	3	4	1	0	3.70
The instructor taught class in a way that helped students make connections to their personal or professional lives	3	4	3	0	1	3.60
Instructor was open to student feedback about the course and instructional methods	2	3	4	2	0	3.40
Overall Average Score						3.94

Table 5. Graduate Student Course Evaluations

Question	Number of Student Response					
	Always (Score: 5)	**Very Often (Score: 4)**	**Sometimes (Score: 3)**	**Rarely (Score: 2)**	**Never (Score: 1)**	**Average (out of 5)**
The instructor taught the subject in way it was easy to learn?	5	2	1	0	0	4.50
Instructor gave clear explanations	5	3	0	0	0	4.62
Instructor asked questions to promote thinking	6	1	1	0	0	4.62
Instructor addressed student questions and comments	6	1	1	0	0	4.61
Instructor provided useful feedback to students	5	1	1	1	0	4.25
Instructor treated student with respect	6	2	0	0	0	4.75
Instructor actively engaged student	7	1	0	0	0	4.88
Instructor engaged students to express ideas or opinions	7	1	0	0	0	4.88
Instructor was prepared for class	6	1	1	0	0	4.62
The instructor communicated course and lesson goals	6	0	1	1	0	4.38
The instructor taught class in a way that helped students make connections to their personal or professional lives	6	2	0	0	0	4.75
Instructor was open to student feedback about the course and instructional methods	6	2	0	0	0	4.75
Overall Average Score						4.64

Based on the general comments, it was clear that some of the undergraduate students struggled with the intensity of the course. They almost, unanimously indicated that the course content was very difficult and data analysis involved in the projects was overwhelming. However the in-class problems, homework problems and overall format of the course assisted the vast majority of undergraduate students in understanding and applying the PMS concepts taught. This was thought of as a major success because PMS courses are very data intensive which, could lead to loss of student interest as concepts may appear abstract. The professor was able to give students an appreciation for the concepts covered in the PMS course by focusing on the application of pavement rehabilitation systems in the latter half of the course. Based on the general comments of the graduate students, both Master of Science and Doctoral students appeared to appreciate the intense nature of the class. They also seemed to appreciate the content covered in the course because it directly applied (in most cases) to their on-going thesis and dissertation research projects.

Summary and Conclusions

The goal of this paper is to disseminate an enhanced methodology and strategy to college instructors that can be successfully employed in a data-driven, project based courses like Pavement Management Systems (PMS). PMS is a course offered in the Department of Civil Engineering at Rowan University's College of Engineering. The objective of the course was to provide a thorough understanding of the pavement management process and demonstrate how concepts of life cycle cost analysis are utilized in the decision making process. The course required students to utilize state of the art approaches that are typically employed by transportation agencies to analyze pavement performance data at the project and network levels. Lectures were conducted with the aid of multimedia presentations and students were often asked to form groups of 2 and participate in classroom assignments. The classroom assignments typically focused on material covered and incorporated authentic PMS scenarios and actual pavement performance data. In the second half of the course, undergraduate students were required to form groups of 3 and develop a data-driven, research, project that compared PMS used in the United States to those used in a developed and developing country. Graduate students were required to form groups of 2, and formulate a research project using pavement performance data from the Federal Highway Administration's Long-Term Pavement Performance (LTPP) database. All groups were then asked to present weekly updates of their respective research projects to the class in order to receive feedback from their peers and instructors. Anonymous course evaluations and independent project evaluations were distributed to the students to assess the effectiveness of the course format, teaching style, and class project in relating concepts of PMS. Based on the feedback provided from the project and course evaluations the following conclusions were drawn:

- Majority of students agreed that the class project helped them to learn about pavement rehabilitation strategies and performance models (i.e., 77% of respondents).
- Students generally liked the format of weekly project presentation updates (i.e. 64% of respondents). This is because the weekly updates provided them with an overall structure for their projects. Students also appreciated the weekly presentations because they were able to obtain constructive feedback from their peers and the instructor.

- Shortcoming of the class project was the open-ended nature of the project. Some students enjoyed the flexibility while other students became frustrated and would have preferred more structure in the project definition.
- Teaching style of instructor and overall class format allowed for PMS concepts to be effectively understood by both undergraduate and graduate level students. This is because the overall course evaluation scores given by both undergraduate and graduate students were good (i.e., 3.94 out of a possible 5 for undergraduate students and 4.64 for graduate students).
- Going forward, some adjustment should also be made in terms of allowing students to provide more feedback about the course throughout the semester. This is due to the fact that the instructor's openness to student feedback received the lowest rating for undergraduate students (i.e., average score of 3.40).
- Some undergraduate students struggled with the intensity of the course with respect to the volume of material covered and data analysis involved in the projects. However the in-class problems, homework problems and overall format of the course assisted an overwhelming majority of undergraduate students in understanding and applying the PMS concepts taught.
- Graduate students appreciated the content covered in the course because it directly applied (in most cases) to their on-going thesis and dissertation research projects.

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