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Improving Students' Learning Outcomes by Solving Open – Ended Problem in Highway Laboratory: Work in Progress

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Abstract: The field of pavement design is dynamic due to the changes in increasing traffic and environmental conditions. The flexible pavement design concept has been selected for this study. The Highway laboratory and the Transportation Engineering courses are offered in the same semester. The paper aims at improving the students learning by carrying out an open – ended experiment in Highway Laboratory, a 1 credit mandate course at B.V.Bhommaraddi College of Engineering & Technology, Hubballi. The theoretical concepts are taught in the course 'Transportation Engineering' which is a 4 credit required course for all civil engineering students. This course provides an introduction to the various aspects of highway engineering, were the author focus is on the design of flexible pavement using mechanistic empirical approach. The work presented in this paper tests the students knowledge on the concept of pavement design by giving an online objective test. The students are assessed at two different stages, one being soon after the completion of theoretical concepts and other after the completion of the open – ended experiment. This work in progress study focuses on comparing the students' learning attainment after undergoing lecture based learning and project based learning. It is expected to have an increased attainment in students learning after performing the open – ended experiment.

Keywords: flexible pavement design, project based learning, lecture based learning, open – ended experiment, learning outcome.

1. Introduction

Transportation engineering is a system which has interconnectivity to the facilities and movements of passengers and commodity. The modal networks are highway, railways, airways and waterways.

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In this paper the author focus on the concepts of flexible pavement design as the field of pavement design are dynamic and continuously changing as it is influenced by the maximum wheel load, subgrade strength of soil and environmental factors. The pavement design involves three aspects such as structural design, functional design and drainage design. The stress and strain values are obtained from structural analysis of the pavement for structural design. The guidelines for the design of flexible pavement were first brought in 1970, which were based on California bearing ratio of soil. The flexible pavement consists of various layers such as subgrade, sub base, base and surface and most common failures were considered in the design of flexible pavements such as fatigue (cracking) and rutting (deformation). The present guidelines are based on mechanistic empirical approach which is revised in 2012, were a concept of using local, recycled and engineered marginal aggregate in the construction has been introduced, as the aggregates are scarce due to depletion of natural resources.

The following are the learning outcomes of the concept under study;
At the end of this study the students will be able to,

- Explain the types of pavements.
- Explain Factors affecting the design of flexible pavements and the concept of Equivalent Single Wheel Load.
- Test the various properties of soil, aggregates and bitumen.
- Carry out traffic volume survey and axle load survey.
- Design the flexible pavement using IRC guidelines.

The work in progress present the students learning outcomes can be improved by assigning an open-ended experiment in a highway laboratory which are evaluated. The first section of the paper gives a brief introduction about the analysis and design of flexible pavement. The second section discusses the methodology adapted for using the theoretical concepts in the open ended experiment. The third section talks about the implementation and results of this methodology. The subsequent sections include conclusions and references.

2. Methodology

The transportation engineering is a 50 hours course which is taught using chalk and talk approach. The course content is tabulated in Table 1. The list of experiments for Highway laboratory is presented in Table 2 and each lab session is conducted for 2 hours.

Table 1. Transportation engineering course content

Unit	Chapter		Hours
1	1	Principles of Transportation Engineering	3
	2	Highway development and planning	5
	3	Highway alignment and surveys	3
	4	Highway geometric design	9
2	5	Traffic Engineering	6
	6	Pavement Materials	6
	7	Pavement design	5
	8	Highway economics	3
3	9	Pavement construction and maintenance	10

Table 2. List of experiments to meet the requirement of course

Experiment		Lab sessions
1	**Demonstration**-Soundness test	1
	Exercise	
2	Impact Test	1
3	Crushing Test	1
4	Abrasion Test	1
5	Shape Test	1
6	Specific gravity & Water absorption Test	1
7	Bulk density & % voids	1
8	Specific gravity of bitumen	1
9	Penetration test	1
10	Ductility Test	1
11	Flash and Fire point Test	1
12	Softening point Test	1
13	Viscosity Test	1
	Structured Enquiry	
14	Marshall Test	1
15	CBR Test on soil	1
	Open ended	
16	Pavement design for Hubballi-Dharwar region	2

In this study an effort is made to compare the students learning outcomes by teaching theoretical concept and assigning a project on theoretical concept as open ended experiment in highway laboratory which is held in 2 sessions. The theoretical concepts were taught on flexible pavement design by using chalk and talk approach. The factors affecting the flexible pavement design, Equivalent single wheel load was explained and thickness of pavements was designed using IRC 37:2001 guidelines. The students learning was assessed using an online objective test, which included 10 questions focusing on the theoretical concepts taught in class.

The Highway Laboratory is structured with experiments as demonstration, exercise, structured enquiry and open ended experiment. The demonstration and exercise experiments focuses on testing the durability and physical properties of aggregates, structured enquiry focuses on designing the bituminous mix and assessing California bearing ratio of soil. In open ended experiment the students are given a series of tasks such as collection of traffic volume data on the Hubli-Dharwar (NH-4) road stretch, axle load survey data for the commercial vehicles plying on the road and collection of subgrade soil sample. The student batches are formed with 16 members in a team and there are total of 5 teams. The students are evaluated based on their team work.

3. Implementation and Results

The class which underwent this study had a total strength of 80 students. The transportation engineering course is a cosmic course in which chapter no 7-pavement design is considered for the purpose of this study. This chapter was taught using chalk and talk approach and presentations in five classes and each class is of one hour. The topics covered in these five classes are presented in Table 3. In the first three classes theoretical concepts related to flexible pavement design were taught with intent of giving the students a pre requisite knowledge. With this pre requisite knowledge the students were made to work on problems related to design of thickness of flexible pavement.

Table 3. Lesson schedule

Class	Topics covered
1	Types of pavements
2	Factors governing the design of pavements
3	Concept of equivalent single wheel load
4	Design of flexible pavement
5	Design of rigid pavement

The online objective test was conducted to test the students learning and the student's response to these questions is given below. This online test was taken up by 60 students.

A. Outcomes of the test after teaching theoretical concept on pavement design:

1. ESWL stands for, Equivalent Single Wheel Load
84% of the students have given the right answer and 16% of them have answered wrong.

2. Which IRC code recommends the guidelines for the flexible pavement design? IRC37: 2012 (revised)
64% of the students have given the right answer and 36% of them have answered wrong.

3. Flexible pavement distributes the wheel load through a set of layers grain by grain contact
80% of the students have given the right answer and 20% of them have answered wrong.

4. The different layers of flexible pavement are subgrade, sub base, base, surface
56% of the students have given the right answer and 44% of them have answered wrong.

5. Contact pressure is (Load on wheel) / (Contact area)
62% of the students have given the right answer and 38% of them have answered wrong.

6. VDF and CSA stands for Vehicle Damage Factor and Cumulative Standard Axles
64% of the students have given the right answer and 36% of them have answered wrong.

7. The IRC method of flexible pavement design is based on CBR method
56% of the students have given the right answer and 44% of them have answered wrong.

8. Rigidity factor is (Contact Pressure) / (Tyre Pressure)
58% of the students have given the right answer and 42% of them have answered wrong.

9. Annual growth rate of commercial vehicles and design life of Flexible pavement as per IRC37: 2001 is 7.5% and 15 years
44% of the students have given the right answer and 56% of them have answered wrong.

10. The IRC37: 2001 is based on mechanistic empirical approach
34% of the students have given the right answer and 66% of them have answered wrong.

The students' response from the online test clearly shows that there is a lot of scope of improvement in the students' learning of different concepts. The author aims at attaining the improvement in students learning through a open ended experiment in highway laboratory. In the highway laboratory the students were made to divide among the sub groups of 5 members in a team among batch. The experiments conducted such as demonstration, exercise, and structured enquiry were evaluated on individual performance and written document submitted after the completion of each experiment. The open ended experiment is divided into four phases and these phases along with the marks distribution are tabulated in Table 4.

Table 4. Phases and marks distribution of open ended experiment

Phase	Tasks	Marks distribution
1	Collection of traffic volume data and axle load survey data.	5
2	Analysis of traffic volume study for design traffic and maximum wheel load.	5
3	Design the thickness of flexible pavement using IRC 37:2012 guidelines	5
4	Presentation and report submission.	5

Currently the students are in Phase 1 of the open-ended experiment. As this study is work in progress the students are advised to complete the remaining phases, post this students will undergo an online test which will include the same set of questions as in the previous test.

4. Conclusions

This work in progress discuss about improving the students learning by teaching the theoretical concept on pavement design and giving an open ended experiment in the highway laboratory on the same concept. It is expected that the students' knowledge will be enhanced by the real world problem and students gets better field exposure after completion of open ended experiment in comparison with theoretical concept.

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