AC 2009-2524: IMPROVEMENT OF GRADUATE STUDENTS' PERFORMANCE IN DESIGN, DISCOVERY, AND LEARNING

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Improvement of Graduate Students' Performance in Design, Discovery, and Learning

Abstract

In this paper we describe how graduate students' performance was improved in design, discovery, and learning. The primary objective of this study is to provide adequate learning experience for the students within the scope of the syllabus for the course. In this study, a course repeated over three years was considered. Students were directed to undertake engineering designs in specialized areas of transportation engineering, technology and management. Design topics related to these areas ranged from Flexible Pavements, Rigid Pavements, Asphalt Paving Technology and Pavement Rehabilitation, to Signalized Traffic Intersections. These topics covered not only conventional transportation systems but also intelligent transportation systems. The students' presentations were peer-graded.

The extent of improvement in design, discovery, and learning was documented extensively by applying appropriate statistical tests. Assessment, grading formula and results are tabulated. The best papers maintained the standards for publication at appropriate local, regional or national conferences.

Introduction

The weakness of the traditional lecture is well established by the regular calls from the academic world to improve the standard of teaching[1-3]. Several students had been complaining to the authors about the weaknesses of the traditional lecture format, including tiredness in the evening classes and lack of interest. These students had been asking the authors to replace the lecture method of teaching at least to some extent by giving them opportunities to think, reason and apply inherent and increased creative abilities. They had been expressing their interest to handle challenging situations and improve their capacity of selecting correct choices from a wide variety of options. The authors were motivated to address these weaknesses.

The motivation of the authors led to a strategy of replacing the lecture method to a considerable extent. This provided the students with more empowerment in various categories of learning such as design, discovery, innovation, and creativity[4, 5].

The objective of this paper is to describe the improvement of graduate students' performance in design, discovery and learning in a transportation technology and management course.

Methodology

A course, CE 5201: Transportation Systems and Management repeated over three years was considered. In the Spring semester of 2003, the course was taught in the traditional lecture format for eleven students. The average grade for this student population was sixty seven out of one hundred. In Fall 2003 eleven students and in Fall 2007 twelve students were taught and given scope for improvement in three categories: design, discovery and learning. In each category students were free to work in any one of the five areas: Flexible Pavements, Rigid Pavements, Asphalt Paving Technology, Pavement Rehabilitation and Signalized Traffic Intersections. Students were free to select their own problem or choose from the data bank of the questions provided to them. While using the data bank questions students need not spend time to collect data because the data was supplied to them. An example of the questions is shown in Table 1.

Table 1. Student Performance in Design

An Open Ended Problem of Designing a Signalized Traffic Intersection
Conduct 6 computer optimization runs using HCS 2000 (latest edition). Submit individual reports. You are provided with options in choosing the following variables on the open ended problem. 1. Signal phasing duration: Red, Green and Yellow timings 2. Design strategy for minimizing the global average vehicle delay of the intersection Answer the following. 1) What is the global minimum intersection delay? 2) Write a report on the project including a critique on the process, progress and results. East-West: Green time= 25-50 Sec., Cycle time= 50-120 sec. North-South: Green time= 35-65 Sec, For each run report the following: 1. Intersection delay 2. Intersection Level Of Service (LOS) 3. Submit a detailed report (15-30 pages) 4. Write a critique on your results (1-2 pages)

In the Design category students were allowed to select a design problem of their choice in one of the five areas. The design problems were reviewed by the instructor for ensuring quality standard of the course. The improvement in performance of the students in discovery included an application of a research paper to a real life problem chosen by the students. In this category,

among other things students were exposed to a large database of research papers. References 6-10 are some examples of the research papers provided to the students.

For the purpose of this study, the category of learning included innovation, creativity, hands on projects and presentation[4, 5]. To create a congenial atmosphere for learning, students were given several challenges and choices. The challenges were: the students should work with what the laboratory had; the students should not use any ready-made commercial parts; their product should not cost more than $300 (excluding their labor) and all the parts of their model must be environmentally safe and recyclable [4,5]. The overall course grading formulas for each course taught in each year are shown in Table 2.

Table 2 Grading Formulas

Criteria	Traditional Method (Percent)	The three Improvement Methods (Percent)
1. Assignments	30	30
2. Attendance and class participation	5	5
3. Examinations - Mid	20	20
Final	45	20
4. Student Improvement project		25
Total	100	100

In order to evaluate the improvements, we need to make sure that we are comparing apples to apples only. This was obtained by replacing twenty five percent of the grade of the final examinations in the traditional method with the same amount of grade in the new method. Except for this, there was no difference between the two methods. This was established by the design of the overall course grading formula shown in Table 2. The traditional lecture format and the three improvement methods have seventy five percent of their grade as the same requirements. All the

courses were taught by the same instructor. The level of difficulty for the seventy five percent of the grade was the same in all the courses.

The t-test is an excellent tool for comparing the means of two groups. Here, one of the groups is control group and other one is a treatment group. Since the t-test is used to determine whether the means are statistically different from each other, this was used to compare the mean of each new method over traditional lecture method. With three or more groups, the t-test is not an effective statistical tool. From the statistical view point, using the t-test for comparing multiple means leads to biased results. In order to find out whether or not all the averages of the set of groups: population, design, discovery and learning are equal, F-test was utilized. An F-test is a statistical test in which the test statistic has an F-distribution if the null hypothesis is true. The hypothesis is that the means of multiple normally distributed populations, all having the same standard deviation, are equal.

Discussion

Table 3 shows the influence of students' improvement in design in the five areas. The average grade was improved from the base value of sixty seven to eighty one. With t-score of 4.74, the p-value is 0.0015, a score that formed the basis to reject the null hypothesis and conclude that the improvement in design made a statistically significant difference on the performance of the students in the course. Notice that the p-value achieved should not be greater than 0.05 in order to establish the statistical significance for the 2-tailed t-test.

Table 3. Influence of Students' Improvement in Design

No. of Students: 11

Lec. Format Grade	Teaching with Students' Improvement							t-Test Score	Statistical Significance @ 0.05 (2-tail)
	Design Areas								
	1	2	3	4	5	Avg. Grade	SD		
67	82	81	78	73	91	81	6.60	4.74	Achieved 0.0015<0.05

Table 4 shows the influence of students' improvement in discovery in the five areas. The average grade was improved from the base value of sixty seven to seventy nine. With t-score of 3.89, the p-value is 0.005, a score that formed the basis to reject the null hypothesis and conclude that the

improvement in discovery made a statistically significant difference on the performance of the students in the course.

Table 4. Influence of Students' Improvement in Discovery

No. of Students: 23

Lec. Format Grade	Teaching with Students' Improvement							t-Test Score	Statistical Significance @ 0.05 (2-tail)
	Design Areas								
	1	2	3	4	5	Avg. Grade	SD		
67	87	69	80	76	83	79	6.9	3.89	Achieved 0.005<0.05

Table 5 shows the influence of students' improvement in learning in the five areas. The average grade was improved from the base value of sixty seven to eighty. With t-score of 3.04, the p-value is 0.015, a score that formed the basis to reject the null hypothesis and conclude that the improvement in learning made a statistically significant difference on the performance of the students in the course.

Table 5. Influence of Students' Improvement in Learning

No. of Students: 23

Lec Format Grade	Teaching with Students' Improvement	t-Test Score	Statistical Significance @ 0.05 (2-tail)
	Design Areas		

	1	2	3	4	5	Avg. Grade	SD		
67	93	68	81	75	85	80	9.5	3.04	Achieved 0.015<0.05

On a practical level, using the t-test to compare many means is a cumbersome process in terms of the calculations involved. Therefore, F-test was used to compare the means of four groups: Population, Design, Discovery and Learning groups. Table 6 gives the detailed statistical results of ANOVA while the summary results of the tests are shown in Table 7. Tables 6 and 7 demonstrate that the students' performances in the four groups are different at statistically significant levels. While analyzing the results of Anova test shown in Table 6, one can notice that the high, low and median values are sixty seven with a standard deviation of 0.0. This means that only one data point is used for the population. It is important to note that even though it is only one data point for the purpose of comparing the groups in the Anova test, it is actually the average of eleven students' performance.

Table 6. Detailed statistical results of ANOVA test on the variables of student improvement.

	Population Average	Design	Discovery	Learning
Mean	67.0	81	79	80
95% confidence interval for Mean	60.61 thru 73.39	74.61 thru 87.39	72.61 thru 85.39	74.01 thru 86.79
Standard Deviation	0.00	6.6	6.89	9.53
Hi	67.0	91	87	93
Low	67.0	73	69	68
Median	67.0	81	80	81

Average Absolute Deviation from Median	0.00	4.4	5	7

Table 7. Summary statistical results of ANOVA test on the variables of student improvement.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F-value
Between	657	3	219	4.82
Error	721	16	45.5	
total	1385	19		

The probability of this result, assuming the null hypothesis, is 0.003.

The new material was peer graded, this may affect the results if the quality of grading is not controlled. In order to achieve acceptable quality control on the grading process, an evaluation rubric as shown in Table 8 was provided to each peer grader. After the peer grading process was completed, the instructor examined whether the graders justified their grades. The deviations in grading, which were rare, were corrected. Thus in each category the student performance improved significantly as demonstrated by statistically significant increases in the overall course grades.

Table 8. Evaluation Rubric for Peer-Graders

Select a current topic within the scope of Transportation Systems and Management course. The following sources are acceptable:

1. Professional journal articles
2. Project reports of corporations.
3. National newspaper articles.
4. Internet sources are acceptable provided they maintain professional standards.

Your project should consist of the following elements:

1. Provide your own critique on how do you improve the performance of the project.
2. Identification of technical and management issues
3. Include the source of the article
4. Organization
5. Summarize the presentation

Criteria	Beginning	Developing	Accomplished	Exemplary
Issues	Most of the issues missed	More than half of the issues presented	Most of the issues presented	All the issues were addressed
Critique	3 or more of the required elements missing	2 of the required elements are missing	1 of the required elements is missing	The importance of the project is described. All the methods and means of improving the project are given.
Organization	Ideas are not presented clearly	Student takes too long to come to the point	Ideas are clear but the presentation lacks organization	The presentation is organized logically.
Summary	3 or more of the required parts are missing	2 or more of the required parts are missing	1 of the required parts is missing	Excellent summary is provided.

Conclusions

The weakness of the traditional lecture is well established by the regular calls from the academic world to improve the standard of teaching. Twenty five percent of the overall grade was replaced by various types of student improvement projects. The improvement projects were in design, discovery and learning aspects of a transportation engineering course at graduate level. In each category the student performance improved significantly. This was demonstrated by statistically significant increases in the overall course grades.

Significance of Conclusions

Approximately only one fourth of the students learn by traditional lecture method. The remaining students learn more if the instructor facilitates their learning process [4, 11]. The conclusions show that similar results may be expected in other courses as well. More detailed study is needed to include a wide variety of courses over several years before recommending this strategy to the widest possible courses offered within the scope of the ASEE Graduate Division.

Recommendations

The following are the recommendations on how these findings would be used in the future for the subsequent offerings of the course. The grade allotted to the improvement projects will be increased from twenty five to thirty five percent. The projects will be expanded to accommodate other tools of learning such as group discussions, presentations and communication skills. There are plans to continue the work presented at least for the next five years.

References

(1) Woods, D. and Crowe, C.M., Characteristics of engineering students in their first two years, Engineering Education, 74, 1985, pp. 289-295.

(2) Boyer, E.L. Assessing scholarship, ASEE Prism, 4, 1995, pp 22-26.

(3) National Science Foundation. America's Academic Future (Washington, DC, National Science Foundation). 1992.

(4) Robert M Brooks a/k/a: James M. Matthews and S.Jahanian, A Pedagogical Strategy for Gradual Enhancement of Creative Performance of the Students, European Journal of Engineering Education, Volume 24, No. 1. 1999.

(5) S.Jahanian and Robert M. Brooks a/k/a James M Matthews, Multidisciplinary Project-A Tool for Learning the Subject, Journal of American Society of Engineering Education, April 1999, pp 153-162.

(6) Michael Berndt, Ali Alkhatani, Mark Meyers, and Christopher Redeagle, Analysis of a Signalized Intersection at Roosevelt Blvd & Grant Avenue, Senior Design Project, CE-1 Team, 2005

(7) Robert M. Brooks a/k/a: James M. Matthews and Carl Monismith, Direct Tension and Simple Stiffness Tests---Tools for the Fatigue Design of Asphalt Concrete Layers, Transportation Research Record No. 1388, Transportation Research Board, National Research Council, Washington, D.C., 1993.

(8) Robert M. Brooks a/k/a: James M. Matthews, Investigation of Laboratory Fatigue testing Procedures for Asphalt Aggregate Mixtures, Journal of Transportation Engineering, American Society of Civil Engineers, Vol. 119, No. 4, 1993.

(9) Robert M. Brooks a/k/a: James M Matthews, The Effect of Aggregate Gradation on the Creep Response of Asphalt Mixture and Pavement Rutting Estimates, American Society for Testing and Materials, STP 1147, Philadelphia, 1992, pp 329-347.

(10) Robert M. Brooks a/k/a: James M Matthews and B.B. Pandey, Performance of Flexible Pavements, Transportation Research Record No. 1307, Transportation Research Board, National Research Council, Washington, D.C., 1991.

(11) Ross, M.L. & Taher (Eds) Explorations in Creativity (New York, Harper & Row), 1967, pp 1-15.