AC 2007-3124: EVALUATING STUDENT LEARNING USING PRE- AND POST-COURSE ASSESSMENT

Yong Bai, University of Kansas

Ph.D., P.E., Assistant Professor, Department of Civil, Environmental, and Architectural Engineering, The University of Kansas. E-mail: ybai@ku.edu

Oswald Chong, University of Kansas

Ph.D., Assistant Professor, Department of Civil, Environmental, and Architectural Engineering, The University of Kansas. E-mail: oswald@ku.edu

Evaluating Student Learning
Using Pre- and Post-course Assessment

Abstract

The Accreditation Board for Engineering and Technology has implemented new criteria for accrediting engineering programs since 1996. Under new criteria, each program must formulate program outcomes that foster attainment of the program objectives and develop an assessment process that demonstrates that these outcomes are being measured and indicates the degree to which the outcomes are achieved. To meet the ABET's challenge, a pre- and post-course assessment method has been developed to evaluate the student learning outcomes and implemented in a senior-level construction course entitled Construction Contracts. The concept of pre- and post-course assessment is quite simple. Students are given a pre-course assessment at the beginning of the semester and a post-course assessment at the end of semester. Each assessment includes a set of questions which covers basic topics of the course. During the development process, the objectives of the course were defined first. Then, 25 true-or-false questions, which cover the basic topics of the course, were developed along with instructions for completing the assessment. Finally, 31 students registered in the course took the pre- and post-course assessment and their performances were recorded for data analyses. The results of the analyses provided valuable inside information regarding the student learning and effectiveness of teaching. Furthermore, the results were used to continue improving teaching efforts since the results showed which topics students had difficulty learning and where the instructor should pay closer attentions in the classroom. Based on these facts, a conclusion is derived that the pre- and post-course assessment is an effective method to assess the learning effectiveness and continue improving the instructor's teaching ability. Because of these features of the pre- and post-course assessment, institutions can use it to demonstrate their performance toward the attainment of ABET's criteria.

Introduction

In 1996, the Accreditation Board for Engineering and Technology (ABET) embarked on a revolutionary accreditation reform effort designed to foster an environment in which each graduate of engineering, technology, computing, and applied science possesses the skills necessary for both lifelong learning and productive contribution to the profession, employers, economy, and society. The centerpiece of this reform was a set of criteria for all ABET disciplines that would allow institutions to be flexible to constituent needs, to allow them to innovate while still maintaining a strong emphasis on educational quality. This reform re-oriented ABET's accreditation philosophy from institution inputs to student outcomes and encouraged constructive interaction with institution constituents to maintain educational quality and relevance. Based on the Criteria for Accrediting Engineering Programs published by the ABET and used for 2006-2007 accreditation cycle, there are eight major criteria that an institution shall meet in order to receive accrediting including[1]: 1) Students, 2) Program Educational Objectives, 3) Program Outcomes and Assessment, 4) Professional Component, 5) Faculty, 6) Facilities, 7) Institutional Support and Financial Resources, and 8) Program Criteria. Under Criterion 3, Program Outcomes and Assessment, ABET specifies eleven (from a to k) attributes that an engineering program must demonstrate that graduates have[1]:

a. an ability to apply knowledge of mathematics, science, and engineering,
b. an ability to design and conduct experiments, as well as to analyze and interpret data,
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability,
d. an ability to function on multi-disciplinary teams,
e. an ability to identify, formulate, and solve engineering problems,
f. an understanding of professional and ethical responsibility,
g. an ability to communication effectively,
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context,
i. a recognition of the need for, and an ability to engage in life-long learning,
j. a knowledge of contemporary issues, and
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

When the old ABET criteria were in place, an institution could almost wait until the year before the accreditation visit to start working on preparation for the visit. This is not to say that institutions could ignore the criteria for six years at a time. However, the bulk of the work required for preparation for a visit would be in the year preceding the visit. With the new criteria to be implemented for accreditation visit, this is no longer the case. Institutions must demonstrate achievement towards goals through various methods such as outcomes assessments, graduate career performance and employer feedback. Institutions are also required to demonstrate continuous improvement. To aid in this ongoing effort, each institution who seeks ABET accreditation shall establish specific educational goals, determine the appropriate outcomes, and develop and implement assessment methods to measure the outcomes. This paper presents a pre- and post-course assessment method which was developed in hopes of providing acceptable levels of assessment to measure program outcomes toward the attainment of ABET Criterion 3, Program Outcomes and Assessment.

Outcome Assessment Background

Outcome assessment has been a major topic of discussion in almost all fields of higher education. The methodologies of assessment have been debated for many years and become more pressing in recent years[2, 3, 4]. Based on the results of literature review, there are several methods that have been used to assess program outcomes. Some of the examples include alumni survey, capstone project, employer survey, fundamentals of engineering (FE) examination, graduate questionnaire, focus group exit interview, and internship report[5, 6, 7]. Since there are eleven attributes in the ABET Criterion 3, it would be impossible to use only one assessment method to evaluate the outcomes toward attaining acceptable performance of Criterion 3. An engineering program has to use assessment portfolio approach, in which multiple assessment methods are utilized, to demonstrate that the program meets the ABET requirements.

Assessment's most powerful point of impact is the individual classroom[8]. Traditionally, many engineering programs have used the student evaluation method to evaluate the individual class and instructor. Although the student evaluation method has value, it is clear that this method

does not provide information regarding how much knowledge students have gained by taking the course. Thus, there is a need to search for a new assessment method that can be used to measure student learning. This is the motivation to develop the pre- and post-course assessment method.

Design of Pre- and Post-course Assessment

The concept of pre- and post-course assessment is quite simple. Students will be given a pre-course assessment at the beginning of the semester and a post-course assessment at the end of semester. Each assessment includes a set of questions which covers the basic topics of the course. Questions in the pre-course assessment and post-course assessment are the same. By comparing the results of pre-course assessment and post-course assessment, the instructor will know some of or all of the followings: 1) if students moving through the courses have the necessary background to be successful without remediation, 2) are students making the knowledge gains the course is intended to create, and 3) what improvements in content and approach could make the course perform better. The results can also be used as indicators to demonstrate whether the students meet some of or all of the requirements of attribute in the ABET Criterion 3.

One of the courses implementing the pre- and post-course assessment is a senior level course entitled Construction Contracts. After taking this course, students are expected to have mastered the following:

1. Legal aspects of contract documents, drawings and specifications,
2. Owner, general contractor, and sub-contractor relationships and responsibilities, and
3. Bidding methods and contract performance.

Achieving these educational objectives, the program demonstrates that its students attain attributes f (an understanding of professional responsibility) and j (a knowledge of contemporary issues) in the ABET Criterion 3. When designing the pre- and post-course assessment for this course, several aspects of assessment had to be considered including:

1. The assessment should measure whether or not the basic information covered by the course had been adequately presented.
2. The format of the assessment should be simple so that it would not require great effort from students to perform the assessment, and
3. The results of the assessment should measure the basic knowledge gain of the students.

Based on these criteria, the instructor developed 25 true-or-false questions to assess the outcomes of the course (see Appendix). These 25 questions cover the major topics of Construction Contracts course, which are not covered in any other courses in the program. The true-or-false format makes it easy for students to conduct the assessment. In order to make sure that the assessment measures the basic knowledge gain of the students, it discourages students from guessing the answers by introducing the following test rules: Each correct answer receives +1 point, no answer receives 0 point, and each incorrect answer receives -1 point. The highest possible score for each student is 25 points.

Implementation and Data Analysis

The pre- and post-course assessments were implemented in a senior level class entitled Construction Contracts. There were 31 students enrolled in the class. The results of the 31 valid sets of data are presented in Table 1.

Table 1 Pre- and Post-course Assessment Data Summary

Items	Question Number																								Sum
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Pre Assessment																										
Correct	23	12	21	15	2	2	1	10	12	3	1	7	6	22	3	18	3	11	8	8	10	4	4	2	8	**216**
Incorrect	0	8	4	3	10	0	18	0	3	2	24	13	16	2	5	6	13	3	3	5	0	5	14	1	0	**158**
No Attempt	8	11	6	13	19	29	12	21	16	26	6	11	9	7	23	7	15	17	20	18	21	22	13	28	23	**401**
Class Score	23	4	17	12	-8	2	-17	10	9	1	-23	-6	-10	20	-2	12	-10	8	5	3	10	-1	-10	1	8	**58**
Post Assessment																										
Correct	29	25	31	27	9	18	13	21	19	27	30	22	20	29	14	25	19	21	24	17	26	15	16	14	26	**537**
Incorrect	0	5	0	2	16	4	14	3	4	0	1	3	10	2	3	4	9	6	3	9	0	11	10	4	3	**126**
No Attempt	2	1	0	2	6	9	4	7	8	4	0	6	1	0	14	2	3	4	4	5	5	5	5	13	2	**112**
Class Score	29	20	31	25	-7	14	-1	18	15	27	29	19	10	27	11	21	10	15	21	8	26	4	6	10	23	**411**

The Correct, Incorrect, and No Attempt rows for pre- and post-course assessments recorded the numbers of students who answered the questions right, wrong, or skipped the questions, respectively. Since each correct answer received +1 point, no answer received 0 point, and each incorrect answer received -1 point, the Class Score was equal to the number of correct answers minus the number of incorrect answers. Comparing the results of pre-course assessment with post-course assessment, see Figure 1, Sum of Correct was up from 216 to 537. Both Sum of Incorrect and Sum of No Attempt were down from 158 to 126 and from 401 to 112, respectively. The sharp decrease of No Attempt indicated that students felt more confident to answer the questions at the end of semester. In the post-course assessment, most of students answered the questions correctly. Few of them answered the questions incorrectly. As a result, the Sum of Correct increased almost 150%. The Class Score was 58 for the pre-course assessment or less than 2 points out of 25 points on average for each student. This score improved to 411 at the end of semester or more than 13 points out of 25 points on average for each student. The large increase of the Sum of Correct and Class Score, and sharp decrease of the Sum of No Attempt all demonstrate the effectiveness of student learning and appropriate mastery of the basic knowledge of students' disciplines after taking the course.

Figures 2, 3, and 4 present more detail comparison between the results of pre-course assessment and post-course assessment. These provide more detailed information regarding student learning. For example, for question number 11 only one student knew the correct answer at the beginning of the semester, but at the end of the semester, 30 out of 31 students gave the correct answer, see Figure 2. This indicates that the instructor taught this particular subject very well during the semester. For some questions such as numbers 5 and 22, the number of incorrect answer increased by 6, see Figure 3. This was a warning sign that the instructor might not have covered these subjects very well during the semester. In the future classes, the instructor should pay closer attention to these subjects to ensure the students understand what is being presented. Thus, the comparison results actually provide valuable information to the instructor in terms of where teaching improvement should be made in the future. More than 10 students made no

attempt to answer question 15 and 24 at the post-course assessment, see Figure 4. This indicated that some students did not know the subjects covered in these questions. Again, these were the indicators that some students might have difficulty learning the material covered in these topics and the instructor should pay closer attention to these subjects in the future.

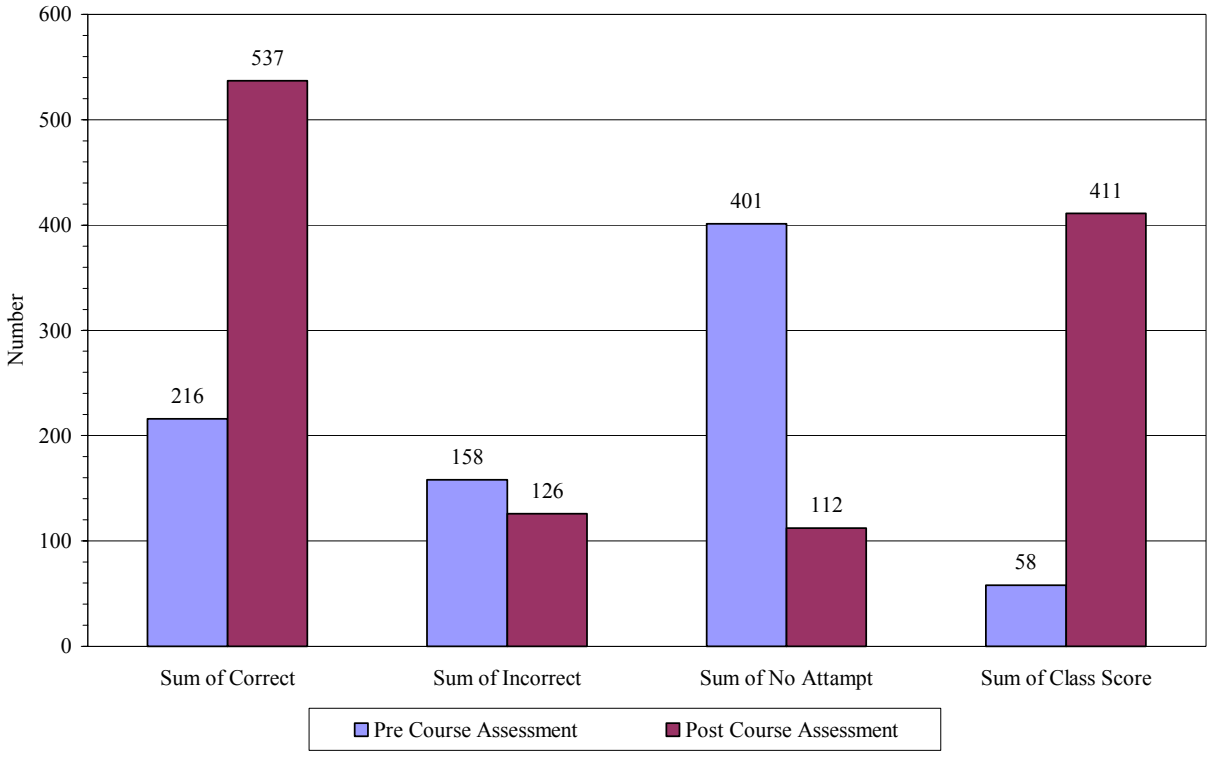

FIG. 1. Pre-course assessment results versus post-course assessment results

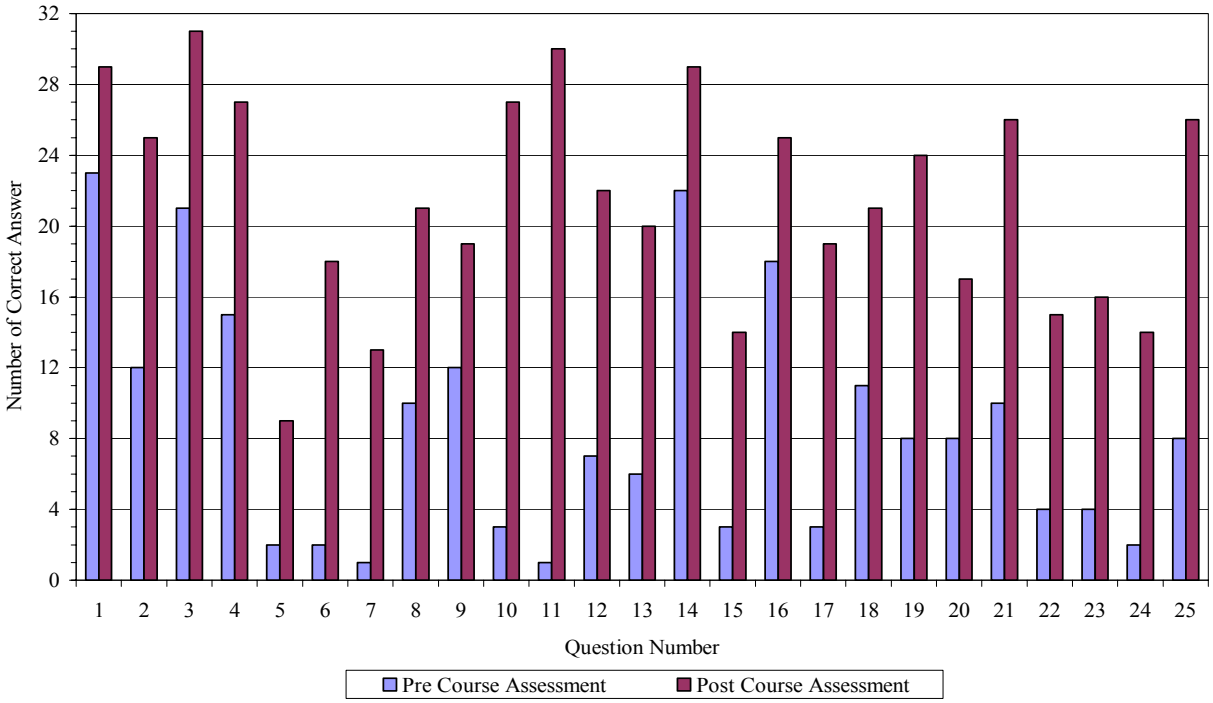

FIG. 2. Pre-course assessment correct answers versus post-course assessment correct answers

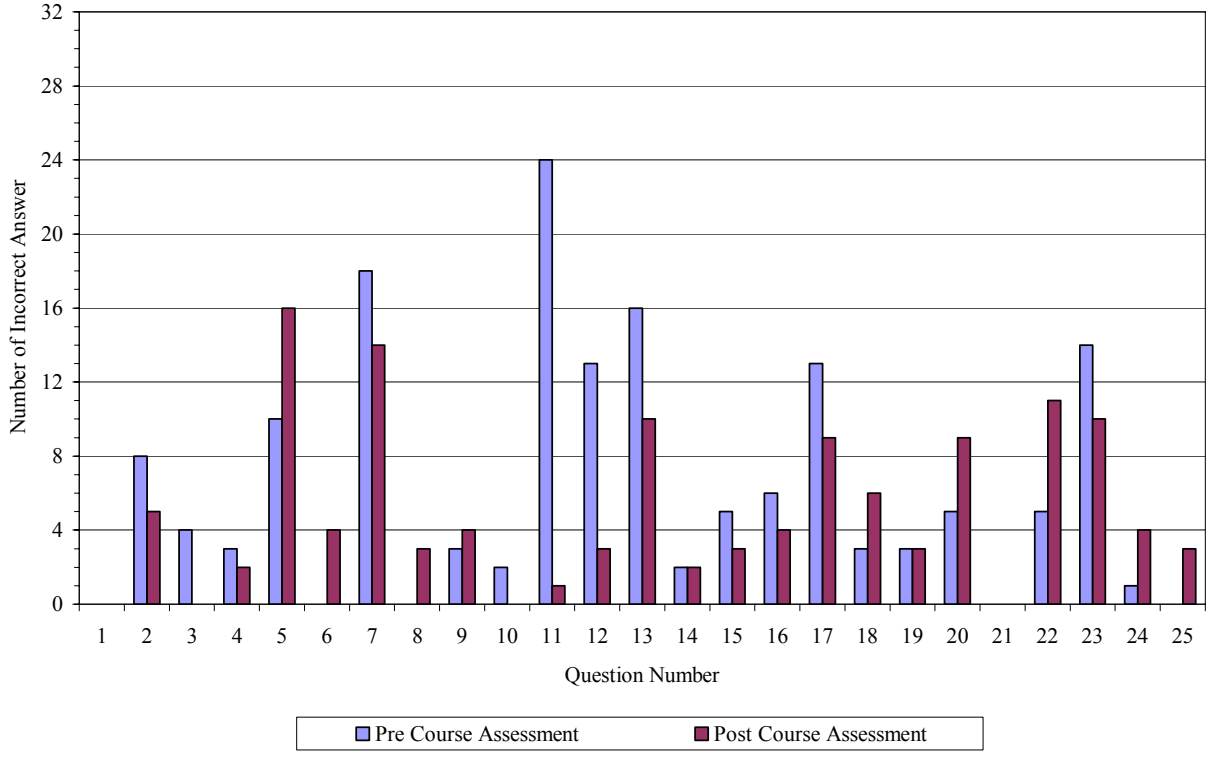

FIG. 3. Pre-course assessment incorrect answers versus post-course assessment incorrect answers

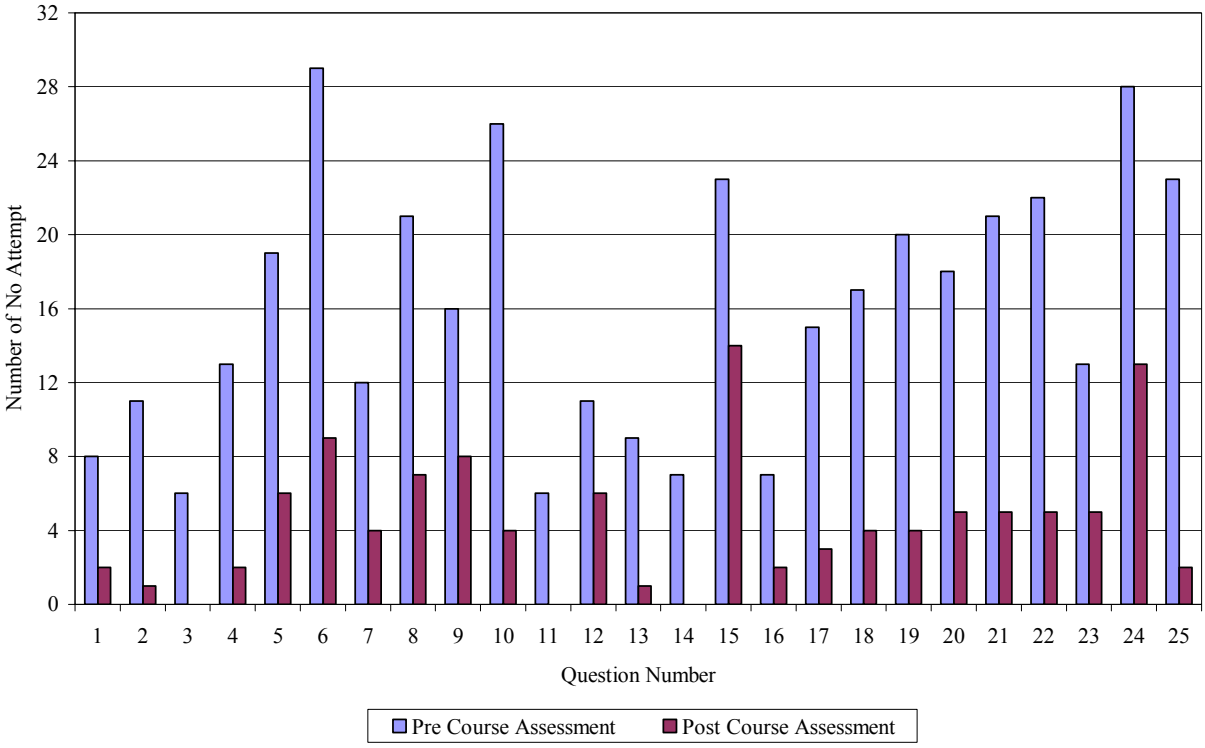

FIG. 4. Pre-course assessment no attempt versus post-course assessment no attempt

Conclusions

The new criteria for accrediting engineering programs have changed the way that engineering programs conduct their business. In order to survive in the future, each program has to develop a strategy to meet the new challenges. The pre-course and post-course assessment method was developed to measure the effectiveness of student learning (outcomes). The method has been implemented in one of the senior level courses entitled Construction Contracts. The results of the data analysis provide valuable inside information regarding the student learning and effectiveness of teaching. The results also demonstrate whether the outcomes of the course have achieved the requirements specified in ABET Criterion. Furthermore, the instructor can use the results to continue improving his/her teaching efforts since the results show which topics students may have difficulty learning and where the instructor should pay closer attentions in the classroom. Based on these facts, a conclusion is derived that the pre- and post-course assessment method is an effective way to assess the course effectiveness and continue improving the instructor's teaching ability. Because of these features of the pre- and post-course assessment method, institutions can use it to demonstrate their performance toward the attainment of ABET Criterion.

Bibliography

1. ABET (2005), "Criteria for Accrediting Engineering Programs," Engineering Accreditation Commission, ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202.

2. Albano, Leonard D. (2006), "Classroom Assessment and Redesign of an Undergraduate Steel Design Course: A Case Study," Journal of Professional Issues in Engineering Education and Practice, ASCE, Vol. 132, No. 4, pp. 306-311.

3. Koehn, Enno "Ed" (2006), "Engineering Experience and Competitions Implement ABET Criteria," Journal of Professional Issues in Engineering Education and Practice, ASCE, Vol. 132, No. 2, pp. 138-144.

4. Baldizan, Maria Elena and McMullin Kurt M. (2005), "Evaluation of Student Learning for an Engineering Graphics Course," Journal of Professional Issues in Engineering Education and Practice, ASCE, Vol. 131, No. 3, pp. 192-198.

5. Bai, Yong and Pigott, Ron (2004), "Assessing Outcomes Using Program Assessment Portfolio Approach," Journal of Professional Issues in Engineering Education and Practice, ASCE, Vol. 130, No. 4, pp. 246-254.

6. Lin, Paul I-Hai and Broberg, Hal (2004), "Capstone Course and Program Outcomes – TC2K Assessment," Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, June 20-23, Salt Lake City, Utah.

7. Wicker, R. B., Quintana, R, and Tarquin, A. (1999), "Evaluation Model Using Fundamentals of Engineering Examination," Journal of Professional Issues in Engineering Education and Practice, ASCE, Vol. 125, No. 2, pp. 47-55.

8. Banta, T. W., Lund, J. P., Black, K. E., and Oblander, F. W. (1996). "Assessment in practice," Jossey-Bass Publishers, San Francisco, CA.

Appendix: Questions of Pre-and Post-course Assessment

1. Law includes court decisions as well as legislative acts.
   T – True F - False

2. Law is a set of rules rather than a process.
   T – True F - False

3. Oftentimes the dispute has no right or wrong but rather is a contest between competing interests, both of which are legitimate.
   T – True F - False

4. One of the construction contracting methods is design-build or turnkey construction. One of the advantages of design-build is that it is possible for construction to begin before completion of the design for the project.
   T – True F - False

5. A contract can be bilateral or unilateral. Most construction contracts are unilateral in that the contractor promises to perform the construction work as specified and the owner promises to pay a stated amount for this work.
   T - True F - False
6. Estoppel is a principle by which a contract becomes binding in spite of the fact that no formal agreement was made between the parties concerned.
   T - True F – False

7. The contractors are required to purchase bonds such as the bid bond and performance bond in order to transfer risk, same as buying the insurance.
   T - True F – False

8. Listing alternates in the lump sum contract has a significant advantage to the owners.
   T - True F - False

9. Extra Work consists of work that is outside and entirely independent of the contract. Additional Work consists of work that must be undertaken to meet the contract requirements and without which the work requested in the original contract could not be completed.
   T - True F - False

10. The term Differing Site Conditions is typically applied to sub-surface conditions
    T - True F - False

11. Construction cannot start until owner and contractor sign the formal contract.
    T - True F - False

12. Since architects and engineers design the project, they always have the right to issue change orders to contractors.
    T - True F - False

13. A working day is universally defined as any day except Saturdays, Sundays, and any holidays.
    T - True F - False

14. The subcontractor receives payment from the general contractor when the general contractor is paid by the owner. If the owner does not pay the general contractor, then the general contractor does not need to pay the subcontractor even the work is properly completed.
    T - True F - False

15. If the construction contract contains no express warranty provision of compliance with the drawings and specifications, such a warranty is automatically inferred or implied.
    T - True F - False

16. Under worker's compensation insurance, compensation is granted for disability and medical treatment for injuries resulting from accidents occurring as a result of employment, regardless of fault.
    T - True F - False

17. In the subcontract, the general contractor will establish a relationship with the subcontractor so that the subcontractor has a direct responsibility to the general contractor but not to the owner. Because of this relationship, the work of the subcontractor must be approved by the general contractor, not the owner.
    T - True F - False

18. The subcontractor is bound to the terms of the general contract in addition to those of the subcontract.
    T - True F - False

19. The amount of liquidated damages can be defined by the court.
    T - True F – False

20. Awarding of subcontract is not dictated by law or public policy even on public projects.
    T - True F - False

21. A contract can be executed or executory. A construction contract is fully executed only after the contractor has completed the construction work in accordance with the contract documents and the owner has paid the contractor for his/her work.
    T – True F - False

22. The right of the federal government or a state or other public agency to take possession of private property and appropriate it for public use can be best described as Lien.
    T – True F - False

23. If the contract time is stated as being 180 days, the contract may state that the contractor must pay $ 1,000 per day for each day the project delivery extends beyond 180 days. This amount is called Fine.
    T – True F - False

24. As a general rule, construction delay caused by force majeure can not be used to claim damages.
    T – True F - False

25. Arbitration is the most popular alternative to litigation. The advantages of arbitration compared with litigation are less time consuming and less expensive.
    T – True F – False