AC 2007-815: INDIVIDUAL COURSE ASSESSMENT AS A CORE ASSESSMENT TOOL

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Individual Course Assessment as a Core Assessment Tool

Abstract

The mechanical engineering program conducts assessment activities largely based on the descriptions and timelines set up in the plan to foster excellence in engineering education. Some assessment activities, such as maintaining student portfolios, require an enormous amount of resources, expertise and time to fully implement and effectively utilize the assessment tools for evaluating students' academic performances. Like almost all small engineering programs faced with the full compliance of the ABET 2000 Criteria, the program decided to select a few assessment tools that can be effectively used and managed by a limited number of faculty and other resources.

The Course Assessment is one of the core assessment tools that had been selected by the faculty eight years ago for specified courses and is now implemented in every mechanical engineering course. This tool is used to evaluate and improve students' academic performances at the same time. The evidence of the assessment activities is documented and filed by the instructor and used for further improvement in following semesters.

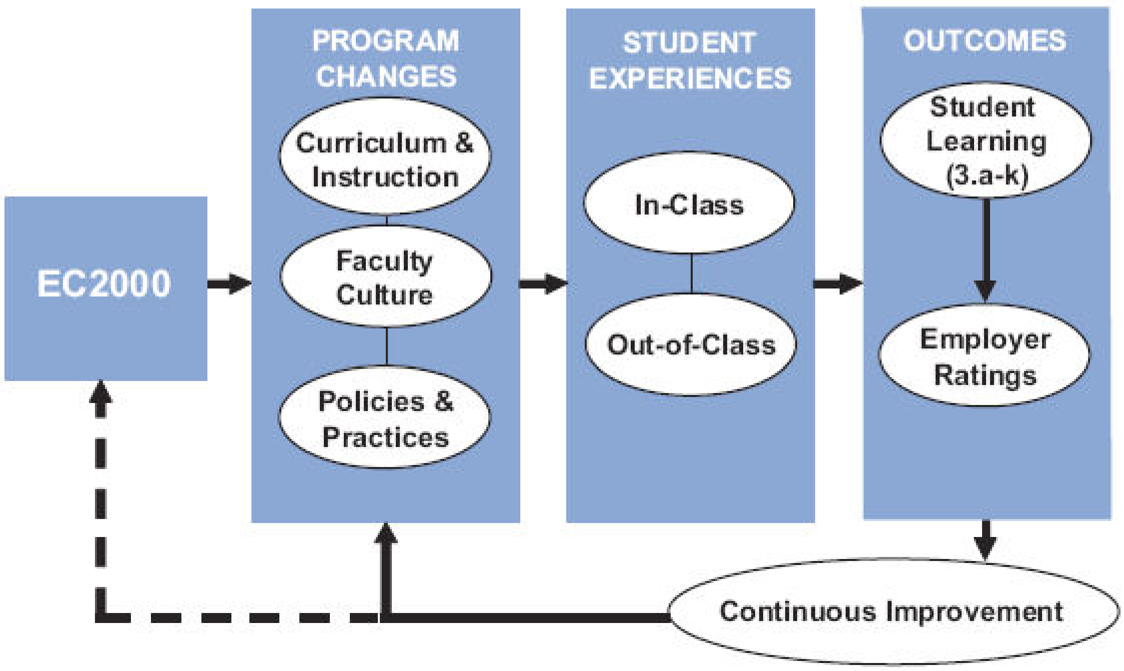
This article documents the Course Assessment applied for a senior-level required course, MECH 4835 Thermal Fluid Applications, over a span of several years. A systematic and innovative course assessment has been conducted, which includes extra evaluations of students' performances, assessment surveys and reviews, reinforcement of selected course materials, and final review of assessment, in addition to regular examinations, homework, and design projects. The assessment activities have been received favorably by students. They felt that the activities helped them gain knowledge effectively and improved their learning curves significantly.

Introduction

In recent years, engineering programs have been striving to improve engineering education by adopting a well defined assessment program and strengthening their commitment to improving the processes and student learning outcomes. ABET adopted the new set of accreditation standards ten years ago. The standards (Engineering Criteria 2000) encompass 11 learning outcomes expected of engineering graduates. The ABET requires all engineering programs to demonstrate their students' achievement and to develop an assessment program that ensures continuous improvement and successful accomplishment of the outcomes.

Although there are other desired outcomes[1] that are added by some schools, accomplishing these learning outcomes are generally accepted by educators as a benchmark for successful assessment. Consequently, most engineering programs adopt an assessment program with a typical feedback loop process[2], as shown in Figure 1. The skills and ability associated with these learning outcomes are essential for the success of engineering graduates. Providing students with opportunities to satisfactorily acquire these learning outcomes, utilizing modern pedagogical tools, is one of the major goals of engineering educators[3].

Figure 1 Continuous Assessment Process



From the Engineering Change Study by Lisa R. Lattuca, et al.

In order to properly implement the process, numerous assessment tools have been employed to measure, evaluate, and improve students' performance outcomes and, ultimately, the success of the assessment process itself. There has been considerable progress made in terms of program changes, faculty cultures, and organizational and educational policies since the year 2000 when the ABET started to evaluate engineering programs under the new criteria. Lattuca, et al. made a three-year study on the impact of the EC 2000 accreditation criteria[4]. They reported that the EC 2000 criteria made a real positive impact on student learning outcomes. They found that improvements in student learning have resulted from changes in the engineering program curricula, teaching methods, faculty practices, and student experiences inside and outside the classroom. They concluded that a student's classroom experiences are the most powerful and consistent influences on the student's learning. This finding is consistent with our conclusion on the effectiveness of the Course Assessment as an assessment tool and as a tool to improve classroom instruction.

Assessment Program

The mechanical engineering program at this medium-sized university is an ABET accredited engineering program and has been continuously accredited for over 50 years. The program was previously evaluated by ABET in 2001 and the next visit is scheduled for Fall 2007. The program has been striving to meet and/or exceed the ABET 2000 accreditation criteria by making continuous improvement of the assessment plan and assessment program.

The assessment plan contains seven program outcomes that include all eleven students' learning outcomes of ABET 2000 Criteria 3a-k. The students' learning outcomes are directly related to the program's educational objectives and contribute to the program in achieving its Mission and goals. The seven student learning outcomes are listed below.

Our students will be able to

1. perform well as mechanical engineers and understand the impact of engineering in a global, societal, and environmental context.
2. identify, formulate, and solve engineering problems by applying fundamental knowledge of mathematics, basic sciences, and engineering sciences.
3. utilize modern engineering techniques, skills, and tools with an emphasis on the role that computers play in the process of solving engineering problems.
4. design and conduct experiments and to analyze and interpret data.
5. design mechanical engineering systems, components, or processes to meet the desired needs.
6. function and communicate effectively both individually and within multidisciplinary teams.
7. understand contemporary issues, professional and ethical responsibility, and the necessity of engaging in life long learning.

Table 1 is a matrix that shows the timeline of the assessment activities and the educational outcomes that the assessment tools must address. There are different levels of assessment tools. The level 1 tool is mainly used for evaluating and improving students' learning outcomes. The level 2 and 3 assessment tools are feedback mechanisms for continuous improvement. They are used to evaluate the educational effectiveness of the mechanical engineering program, based on the data collected from the level 1 tool, which facilitate to set the new direction and to implement the new assessment plan.

The assessment program of this department is similar to those of other engineering programs. The program conducts a variety of assessment activities laid out by the assessment plan to foster excellence in engineering education. These assessment activities involve all constituents that consist of students, faculty and staff, administrators, alumni, employers and the public, and are coordinated by the assessment director or chair of the department. As pointed out in the study [2] mentioned earlier, one of the most efficient and direct results to achieve students' learning comes through an efficient teaching and learning in the classroom. The course assessment can help the faculty improve their teaching by strengthening the engagement between the faculty and students. While continuing to improve every assessment activity and the overall assessment process, the faculty of this department has concluded that strengthening the process of individual course assessment is the most effective way to accomplish the EC 2000 criteria.

Table 1 Timeline of Assessment Activities

Assessment Tools	Timeline (Year of latest assessment)	Assessed By	LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7
Level 1 Tools									
Course Assessment	Semester (F06)	Faculty	x	x	x	x	x	x	x
Standard Test (FE Exam)	Annual (2006)	Director	x	x					
Exit Interviews and Survey	Semester (F06)	Director	x	x	x	x	x	x	x
Alumni Survey	Annual (2006)	Director	x	x	x	x	x	x	x
Industry Survey	Every 3 years(2003)	Director	x	x	x	x	x	x	x
Co-op/Internship Evaluation	Semester (F06)	Director	x	x	x	x	x	x	x
Capstone Design Evaluation	Annual (S06)	Faculty	x	x	x	x	x	x	x
Student Focus Group	Annual (2006)	Director	x	x	x	x	x	x	x
Rubrics	Annual (2006)	Director	x	x	x	x	x	x	x
* Level 2 and 3 Tools									
Industrial Advisory Board	Annual (2006)	IAB							
Program Curriculum Review	Annual (2006)	Faculty							
Strategic Planning	Every 3 years (2006)	Chair							
YSU PAC Review	Every 5 years (2003)	Faculty							
ABET Review	Every 6 years (2001)	Faculty							
NCA Review	Every 10 years (1998)	Faculty							

The Course Assessment

The Course Assessment is one of the core assessment tools that was incorporated into the assessment plan eight years ago for a limited number of courses and is now implemented in every mechanical engineering course. Each course deals with different aspects and stages of students' learning. Therefore, each Course Assessment addresses specific learning outcomes listed above in Table 1.

The faculties use this assessment tool to measure, evaluate and improve students' learning outcomes defined in the course syllabus. Each faculty member designs and uses his/her own assessment methods for the course, although a standard format and standard forms have been developed over the years by the assessment coordinator and suggested for use to the faculty. The assessment includes self designed questionnaires and short quizzes for assessment purposes. The short quizzes are closed book tests that deal with questions regarding concepts or fundamentals. These surveys and quizzes are given to students unannounced, two or three times, at different phases in the semester to check the progress of students' academic performances. The data, along with regular test results and homework, are evaluated by the faculty to investigate whether students' learning outcomes have met the course objectives and goals. Some corrective measures, including handing out supplementary materials and/or giving additional reviews, are taken during the semester. At the end of the semester, the faculty member reviews all activities of the Course Assessment and rates the level of competency of students. In addition, the evidence of the assessment activities is documented and filed by the instructor within two weeks after the semester ends. In the beginning of the following semester, the summaries of assessment results are further reviewed collectively at the faculty meeting and corrective measures for curriculum and policy changes are recommended.

The author initiated the Course Assessment for the department in Fall 1999 and began conducting the assessment for his courses. He continued for five consecutive years until Spring 2004 when he was awarded a sabbatical for the following year. He resumed his teaching in Fall 2005 and his Course Assessment. As described in the previous paragraph, he designed the assessment process and timeline to administer necessary assessment activities. The survey forms and quizzes were developed and fine tuned as more experiences are accumulated. For illustration, the assessment materials used for a senior-level course, MECH 4835 Fluid Thermal Applications, are attached as appendices. The materials include the outcome assessment, survey on students' learning progress, assessment quiz, and the final survey.

Initially he was not sure of the effect of the Course Assessment. However, as he continued conducting the assessment and improving the process for the same courses over the years, he began to see the positive impact the Course Assessment brings to his instruction and students' learning. The activities through the Course Assessment directly contribute to strengthening the level of student faculty engagement and developing instructional practices that produce desirable results in students' learning outcomes. Although it is difficult to provide a quantitative proof for the positive impact of the Course Assessment on students' learning, he is convinced that the assessment has at least partially contributed to higher passing rates of graduating classes taking the Fundamentals of Engineering Examinations. Approximately 60% to 70% of the graduating seniors take the FE Exam in Spring of their senior year and 90% pass the Exam. In Spring 2004, 21 students of 22 graduating seniors took the Exam and 19 students passed. It is noted that the assessment activities may contribute to improving students' evaluation of faculty's teaching.

The Course Assessment in Other Courses

The course assessment conducted by other faculty members showed a generally positive feedback from the faculty and students that have been similarly encountered in the author's assessment in the past few years. The followings statements detail a faculty member's response and plan to accommodate students' needs in the future to improve students' academic performance in his stress analysis course[7].

- Students were weak in stress analysis as they entered the course. Some never really got the basics completely understood.
- Design projects worked out better, due to time spent in the lab sessions.
- Software skills were aided greatly over the last few years with help sessions given in the lab. Also, more independent work with the software was required, so students needed to actually do the model development rather than depend on the instructor to build the models.
- The course instruction should keep to the schedule more to avoid cramming at the end of the term. This is due to large class size with 40 students. Out-o-class problem sessions were held most weeks. These helped immensely for those who attended.
- Class ran better than in previous years. Weaker students still holding things back, but were not allowed holding back the class. Instruction must not linger along for weak students. Grading was changed to have exams carry more weight than in past years, compared to homework. This is a change that was suggested last year and implemented with favorable results. Some students still do not get a good understanding of the material, but their grade now accurately reflects this fact.

Another faculty member's course assessment revealed that at least three quarters of students in her course achieved the course objectives and close to 100% of students demonstrated the abilities in formulating and solving engineering problems and in utilizing modern tools and skills. That was a substantial improvement over the previous years' results. Her comments on the assessment and plan of changes in the future to improve students' performance in the same course are summarized as follows[8]:

- Design projects continued to prove difficult for students. Help sessions scheduled to assist students were not well attended, due to time constraints from other courses and job situations.
- May want to include graded closed-book assessment quizzes prior to each exam to be sure of global understanding of material and the most basic of fundamentals. Final assessment survey showed a lack of understanding and effort.
- Need more real world examples of control systems. Need a PID controller operating on a real system for class or lab demonstrations to improve student's interest and relationship to theory presented in class.

Conclusion

The Course Assessment is one of the core assessment tools that can directly contribute to improving students' learning outcomes. This tool is used to evaluate and improve students' academic performances at the same time. They include extra evaluations of students' performances, assessment surveys and reviews, reinforcement of selected course materials, and final review of assessment, in addition to regular examinations, homework, and design projects. By conducting the assessment activities, faculty members are motivated to provide significant levels of personal dedication. They become more inclined to devise systematic and innovative pedagogical methods for active learning. In addition, as pointed out by recent articles[1, 5, 6], the Course Assessment facilitates:

a) student-faculty interaction
b) communication
c) feedback
d) understanding of fundamentals
e) engineering reasoning

The assessment activities have been received favorably by students. They felt that the activities helped them gain knowledge effectively and improved their learning curves significantly. That sentiment is well reflected in the final assessment surveys. The ratings have been improving gradually since the course assessment has been implemented. The Course Assessment is one of the most efficient and economical assessment tools that a small or medium-sized engineering program can effectively incorporate as a core assessment tool to achieve students' learning outcomes and the educational objectives of the program.

Bibliography

1. S. Bjorklund and N. Fortenberry, "Measuring Student and Faculty Engagement in Engineering Education", CASEE Report, National Academy of Engineering, 2005.
2. L. Lattuca, P. Terenzini, and J. Volkwein, "Engineering Change: A Study of the Impact of EC 2000", Pennsylvania State University, 2006.
3. B. Olds, B. Moskal and R. Miller, "Assessment in Engineering Education: Evolution, Approaches, and Future Collaborationa", Journal of Engineering Education, V. 94, No.1, 2005.
4. 2003-04 Criteria for Accrediting Engineering Programs, ABET, Baltimore, MD 2002.
5. S. Bjorklund, J. Parente, and D. Sathianathan, "Effects of Faculty Interaction and Feedback on Gains in Student Skills", Journal of Engineering Education, v.93, no. 2, 2004.
6. P. Richard, R. Niewoehner, and L. Elder, "Engineering Reasoning", Foundation for Critical Thinking, 2006.
7. D. Suchora, "Report on Course Assessment", Mechanical Engineering Program, Youngstown State University, Fall 2006.
8. H. Marie, "Report on Course Assessment", Mechanical Engineering Program, Youngstown State University, Spring 2005.

Appendix 1

Outcome Assessment for Individual Course
in
Mechanical Engineering Program

Course No. & Title: MECH 4835 Thermal Fluid Applications
Term: Fall 2006 **Instructor:** XXX
Course Objectives:
To provide mechanical engineering students with a first-hand experience in the analysis and design of systems that involve combination of the principles of thermodynamics, heat transfer, and fluid dynamics. On successful completion of this course, students are expected to

1. understand the energy losses in a variety of piping systems
2. solve the head loss problems for pipes in series and parallel
3. solve the head loss problems in general network of piping
4. understand the fundamentals of heat exchangers
5. analyze and design shell and tube heat exchangers
6. analyze and design cross-flow heat exchangers
7. understand the theory of turbomachinery
8. solve problems related to centrifugal pumps and fans
9. select appropriate pumps and fans for the system, and determine operating point
10. analyze and simulate piping systems with prime movers
11. be capable of utilizing software
12. design a thermal-fluid devices, machinery, or systems in an open-ended setting.

Assessment methods and tools used in this course:

1. Examinations
2. Homework
3. Projects
4. Student surveys on self evaluation
5. Assessment quizzes

Were the course objectives met? Answer this by indicating the percentage of the students who achieved the course objective?

Objective	Assessment tools	At least 70%	At least 80%	At least 90%
1	1, 2, 3, 4, 5			X
2	1, 2, 3, 4, 5			X
3	1, 2, 3, 4, 5		X	
4	1, 2, 3, 4, 5			X
5	1, 2, 3, 4		X	
6	1, 2, 3, 4	X		
7	1, 2, 3, 4, 5			X
8	1, 2, 3, 4		X	
9	1, 2, 3, 4			X
10	2, 3, 4		X	
11	2, 3, 4			X
12	2, 3, 4	X		

Program outcomes measured through the assessment tools:

1. Program outcome 1: successful mechanical engineer
2. Program outcome 2: formulate and solve engineering problems
3. Program outcome 3: modern tools and skills
4. Program outcome 5: design mechanical engineering systems or components
5. Program outcome 6: communicate and function well in teams

How well were the Program outcomes met? Answer this by indicating the percentage of the students who achieved the Program outcomes?

Program outcome	Assessment tools	At least 70%	At least 80%	At least 90%
1	1, 2, 3, 4, 5			X
2	1, 2, 3, 4, 5		X	
3	1, 2, 3, 4			X
5	2, 3, 4	X		
6	2, 3, 4			X

What did you do to correct the deficiencies revealed above?

1. Some students did not have clear-cut understandings on fundamentals or could not articulate basic concept of physical mechanisms and mathematical expressions. I spent extra sessions for reviewing several topics that students showed weakness and indicated difficulty in comprehending, including the Hardy Cross method and cross-flow heat exchangers.
2. Generally, students' ability of utilizing software is excellent. I promoted Matlab and Excel to improve students' ability of problem solving and engineering design.
3. Students still show weakness in initiating and carrying out their own design projects. Many examples of real design problems were illustrated.

What would you change in the future to improve students' performance in your course?

1. "Analysis and Design of Energy Systems, 3rd Ed," authored by Hodge and Taylor was readopted as a textbook after experiencing less successful result with a couple of textbooks in the previous years. Although the book has its own deficiency in the cumbersome unit conversion and Mathcad programming, it is, in my opinion, better than other textbooks available in the market.
2. Fundamentals in the unit conversion, energy conservation, head losses, heat exchangers, and prime movers will be examined more rigorously.
3. Simulation and investigation of entire fluid-thermal systems will be emphasized. I must find good commercial software that can maximize students' learning outcome. Design project must include comprehensive simulation requirement next year.
4. More closed-book pop quizzes will be used to reinforce students' understanding of very basic fundamentals. The weight of pop quiz will be increased.

Appendix 2

MECH 4835 THERMAL FLUID APPLICATIONS ASSESSMENT Fall 2006

INITIAL ASSESSMENT ACTIVITIES FOR CONTINUOUS IMPROVEMENT

In the course syllabus, several learning goals/anticipated outcomes were specified so that each student, upon completion of the course, demonstrates the desired level of comprehension and achievement. There are a few effective thinking processes and good study habits that will help you achieve these learning goals. At the very beginning of this course, I would like to suggest what I consider good practice for effective learning and would also like to hear from you regarding what you expect of me in order to facilitate the process.

What I expect of you:

1. Attend the class.
2. Bring the text and notebooks.
3. Read articles prior to class time.
4. Be attentive and respect other people in class.
5. Try to understand the phenomena on physical grounds or with common sense first.
6. Be able to interpret mathematical expressions into physical meanings.
7. After a thorough comprehension of basic concepts, memorize key terminologies and definitions, and, if possible, most fundamental equations in its simplest form.
8. Do homework early or daily.
9. Preview the assigned problems, arrange your thoughts and ideas, and have questions ready to discuss in class.
10. Develop or follow a suggested process of solution methodology.
11. After solving a problem, interpret the results and check the process.
12. Submit your homework on time.

What do you expect of me?

1.

2.

3.

Assignment:

Please return this sheet with your response on Tuesday, September 6, 2006, along with a 200-word essay that describes anything related to thermodynamics or heat transfer and the way you perceive on the physical phenomenon. The essay must be typewritten (or word-processed) on the back of this sheet.

Appendix 3

MECH 4835 THERMAL FLUID APPLICATIONS **FALL 2006**

ASSESSMENT SURVEY #1 FOR COURSE ASSESSMENT

In the course syllabus, several learning goals/anticipated outcomes were specified so that each student, upon completion of the course, demonstrates the desired level of comprehension and achievement. Since this marks the end of a phase of the course, it seems an appropriate time to investigate whether the essential concepts and/or skills have been acquired to each student's satisfaction. Please check those concepts and skills listed below that you think further clarification is needed. Based on this survey results, time will be taken to review the material identified by students.

Piping System	Review needed
Head loss equation in SI system of units	____________
in British Engineering units	____________
Physical meaning of each terms	____________
Major and minor head losses	____________
Darcy-Weisbach and Fanning friction factors	____________
Moody chart, general characteristics of	____________
Pressure losses in pipes	____________
Relationship between pressure and head losses	____________
Pipes in series, major principles for	____________
Pipes in series, problem solving for	____________
Pipes in parallel, major principles for	____________
Pipes in parallel, problem solving for	____________
Pipes in general networks, major principles for	____________
Pipes in general networks, problem solving for	____________
Kirchhoff's Current Law at nodes	____________
Kirchhoff's Voltage Law for loops	____________
Hardy Cross method, concept	____________
Hardy Cross method, application	____________
Generalized Hardy Cross method, application	____________
Computer programming, Excel	____________
Computer programming, Matlab	____________

Appendix 4

MECH 4835 THERMAL FLUID APPLICATIONS FALL 2006

QUIZ #1 FOR COURSE ASSESSMENT

In the course syllabus, several learning goals/anticipated outcomes were specified so that each student, upon completion of the course, demonstrates the desired level of comprehension and achievement. Since this marks the end of a phase of the course, it seems an appropriate time to investigate whether the basic concepts of essential skills have been acquired to each student's satisfaction. Please answer to the following questions that are designed for short answers.

Piping System

1. Write a head loss equation in the British engineering system of units between two sections, say 1 and 2, in a piping system.

2. What flow phenomenon causes major head loss?

3. Write the major head loss, h_l for a flow at the velocity of V through a pipe of D and L?

4. In a fully developed turbulent flow, what is the friction factor f a function of?

5. What flow phenomena cause minor head losses?

6. List two physical principles used on the flow rate and head loss in solving pipes in series.

7. Do the same for pipes in parallel.

8. Do the same for pipes in general network.

9. What is the pressure loss for a flow through a horizontal, constant cross-sectional pipe with the total head loss of h_l?

10. What is the power necessary to make the above-mentioned flow?

Appendix 5

MECH 4835 THERMAL FLUID APPLICATIONS **FALL 2006**

FINAL ASSESSMENT SURVEY FOR COURSE ASSESSMENT

In the course syllabus, several learning goals/anticipated outcomes were specified so that each student, upon completion of the course, demonstrates the desired level of comprehension and achievement. Since this marks the end of the course and the associated laboratory, it seems an appropriate time to investigate whether those outcomes have been achieved to each student's satisfaction.

A short survey form is developed to gather your opinion on these courses in an attempt to improve the quality of the teaching and learning process. Please answer the following questions carefully by circling a number for each question with 1 for disagree, 2 for neutral, and 3 for agree.

		Rating	
1. The material contents of the lecture course were generally too much.	1	2	3
2. The material in the following subject should be covered more in depth			
Review on thermo, fluid, and heat transfer	1	2	3
Head loss equations and the units conversion	1	2	3
Head losses in series of pipes	1	2	3
Head losses in parallel of pipes	1	2	3
Hardy Cross method for general piping networks	1	2	3
Computer programming for piping-system analysis	1	2	3
Theory of heat exchangers	1	2	3
Design analysis of shell and tube heat exchangers	1	2	3
Design analysis of cross-flow heat exchangers	1	2	3
Theory of turbo-machinery	1	2	3
Characteristics of centrifugal pumps	1	2	3
Selection of pumps	1	2	3
Operating conditions of multiple pumps in a system	1	2	3
Fans and blowers	1	2	3
3. I consider the design project as a more efficient learning tool	1	2	3
4. The course design project should be changed to an individual project	1	2	3
5. The lab design project is a good idea	1	2	3
6. I did not have sufficient exposure to the following activities and they should be expanded.			
The review of speech making	1	2	3
The impromptu speech session	1	2	3
The oral report on the project proposal	1	2	3
The group discussion on an experiment	1	2	3
The formal presentation	1	2	3
The critical review	1	2	3
7. The oral activities replacing the written report requirement is a good idea.	1	2	3