A Course Assessment Tool for A Mechanical Engineering Design Class

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Abstract

A course assessment questionnaire was designed and used as an assessment tool for evaluation of a design-based and team-oriented mechanical engineering senior design course. The student feedback to the evaluation questionnaire was collected and analyzed to gain a better understanding of how well this course met the learning needs of students and addressed the goal of developing their career skills, as well as its impact on ABET educational objectives, upon which a plan to improve this senior design course would be formulated. The designed assessment questionnaire is a good supplement tool to the regular student evaluation form as a means to gather more insightful and valuable information from students for this specially designed course, through which the additive value of the unique industry-tied and team-oriented education mode implemented in that course can be correctly evaluated.

Keywords

Course assessment, questionnaire, mechanical systems design, ABET

1. Introduction

An industry-tied and team-oriented mechanical systems design course had been previously developed and offered to senior students at Mississippi State University (MSU) (Liu and Dou 2015, Liu 2017). In that course, design projects provided and sponsored by industrial partners, research centers, and state agencies were assigned to student teams and used as an effective device to improve student capacity of solving real-world engineering problems and develop their career skills in a multidisciplinary environment. In order to assess and improve teaching approaches, learning materials, and education model implemented in that course, an effective student evaluation instrument was needed. However, the currently used course evaluation questionnaire is too simple to allow the instructor to collect all useful information from the students to evaluate that if the specific aims of this course have been achieved and to determine what specific modifications need to be made to improve the effectiveness of that course. A powerful evaluation questionnaire which enable the instructor to obtain a comprehensive understanding of advantages and shortcomings of the renovated design course needs to be constructed. In particular, the evaluation questionnaire should be able to effectively assess the unique industry-tied and team-oriented education mode implemented in that course.

In this study, we designed and constructed an evaluation questionnaire to effectively evaluate the quality of the mechanical systems design course, especially measure the industry-tied and team-oriented education mode and determine the effectiveness and efficiency of the group design project in improving students' skills in problem solving and multidisciplinary team working.

2. Design of A New Assessment Instrument

An improved assessment instrument was designed, which includes four sessions. The first session is about the achievement of the course goals, including 10 closed-format questions and two open format questions. In the session the students are asked to evaluate their growths on following skills, organization, teamwork, communication, leadership, management, and problem solving as well as the knowledge development on topics of solid mechanics, fluid mechanics, manufacturing, and CAD/CAE. The second session uses four open format questions to obtain more information about the nature of the project that each student team worked on. The acquired information can provide additional details related to their motivations, knowledge gains, and skill performances of this course. The third session with its 10 closed format questions on a 6-point Likert scale aims at finding out student perception of industry importance on the skills and knowledge covered in this course. The collected results can be used to assess their possible motivation for mastering different skills and topics associated with employability and industry standards.

A fourth session was added to discuss the impact of the renovated course on ABET educational goals. Student perceptions of course performance for ABET criteria would enhance the assessment of the course by expanding the prior formative and summative assessments to detail specific ABET measures. Thus, the ABET assessment part of this survey was designed to examine the rationale and motivation for learning gains, student perceptions of preparation and awareness of the ABET criteria inclusion within this design course. 11 closed format questions on a 5-point Liker scale were added to assess the student outcomes according to the 11 ABET (a-k) educational objectives. Finally, each student is asked to write down their additional comments on this course.

This survey was conducted in the fall semester of 2016 and 44 senior students enrolled in that class participated in the survey. All the questions, student evaluation results for the closed format questions are listed in the next section.

3. Assessment Results

3.1 Course Goals

In the **Before Course** column rank your level for each skill and knowledge of each topic before the course and on the **After Course** column rank how you think you are now that you have completed the course. The number 1 represents the lowest ranking and 5 represents the highest ranking for each skill and topic. The numbers in the cell represent the number of student who chose that point. For example the "13" in the row of "Organization" means that 13 students selected "3" for that question.

Table 1. Assessment and results on course goals

	Before Course August 2016					**Over all**	**After Course** November 2016					**Over all**	**Δ**
Skills	1	2	3	4	5	**5**	1	2	3	4	5	**5**	
Organization		1	13	21	9	**3.86**			6	25	13	**4.16**	**0.3**
Teamwork		1	6	25	12	**4.16**			3	19	22	**4.43**	**0.27**
Communication	1	1	12	18	12	**3.89**			3	22	19	**4.36**	**0.47**
Leadership	1	3	15	14	11	**3.70**			9	20	15	**4.14**	**0.44**

Project Management	1	3	14	18	8	**3.66**		1	4	20	19	**4.30**	**0.64**
Problem Solving		1	10	24	9	**3.93**			3	21	20	**4.39**	**0.46**
Topics	1	2	3	4	5		1	2	3	4	5		
Solid Mechanics		3	19	19	3	**3.50**		1	4	28	11	**4.11**	**0.61**
Fluid Mechanics		10	22	6	6	**3.18**		7	21	11	5	**3.32**	**0.14**
Manufacturing		4	17	18	5	**3.55**			7	28	9	**4.05**	**0.5**
CAD/CAE		3	17	17	7	**3.64**		1	8	25	10	**4.00**	**0.36**

- Which, if any, skills or topics did you note an increase? What do you think lead to your increase in that area?
- Which, if any, skills or topics did you note a decrease? What do you think lead to your decrease in that area?

3.2 Industry Importance

Use the following table to rank the skills and topics in order of importance for industry according to your experiences and perceptions. The number 1 is the most important and number 6 is the least important. Use each number 1, 2, 3, 4, 5, 6 only once for each set. The numbers in parentheses represent the number of students that selected the scale before the parentheses. For example, 1(6) means that there were six student choosing "1" for a particular question.

Table 2. Assessment and results on industry importance

Skills	Skill Ranking (1 – 6)	**Overall scores**
Organization	1(6), 2(7), 3(7), 4(6), 5(5), 6(13)	**3.82/6**
Teamwork	1(12), 2(8), 3(6), 4(8), 5(2), 6(8)	**3.09/6**
Communication	1(9), 2(13), 3(6), 4(2), 5(4), 6(10)	**3.20/6**
Leadership	1(4), 2(4), 3(5), 4(9), 5(11), 6(11)	**4.23/6**
Project Management	1(6), 2(10), 3(5), 4(6), 5(11), 6(6)	**3.55/6**
Problem Solving	1(6), 2(7), 3(9), 4(6), 5(7), 6(9)	**3.64/6**
Topics	Topic Ranking (1 – 6)	
Solid Mechanics	1(9), 2(13), 3(8), 4(5), 5(6), 6(3)	**2.89/6**
Fluid Mechanics	1(4), 2(3), 3(9), 4(5), 5(12), 6(11)	**4.16/6**
Manufacturing	1(13), 2(7), 3(6), 4(10), 5(4), 6(4)	**2.93/6**
CAD/CAE	1(4), 2(3), 3(6), 4(6), 5(6), 6(19)	**4.45/6**

3.3 Student Outcomes

Please mark the cell that best describes your response to the following statements about how this course met each of the following ABET criteria.

Table 3. Assessment results of the course's impact on ABET outcomes

This course has provided me with	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	**Overall scores**
A. An ability to apply knowledge of mathematics, science, and engineering	21	18	4		1	**4.30**
B. An ability to design and conduct experiments, as well as to analyze and interpret data	20	19	4		1	**4.30**
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	22	18	1	2	1	**4.32**
D. An ability to function on multidisciplinary teams	13	22	6	2	1	**4**
E. An ability to identify, formulate, and solve engineering problems	26	16		1	1	**4.48**
F. An understanding of professional and ethical responsibility	20	20	3		1	**4.32**
G. An ability to communicate effectively	19	20	4		1	**4.27**
H. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	17	14	10	2	1	**4**
I. A recognition of the need for, and an ability to engage in life-long learning	24	14	4	1	1	**4.34**
J. A knowledge of contemporary issues	13	16	12	2	1	**3.82**
K. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	25	17		1	1	**4.45**

4. Analyses and Discussions

4.1 Effectiveness on Skill Growth and Knowledge Development

Based on Table 1 it can be found that all the listed skills and knowledge of the participating students were improved through this course. The students identified that they had achieved biggest improvements on the project management skill and their solid mechanics knowledge. This can be attributed to the implementation of the team-based design projects and the fact that this systems design course focused more on the solid mechanics, including mechanical components design and analysis. The least improvements they made in this class include the fluid mechanics knowledge and the teamwork skill. This is because that the course syllabus did not cover many fluid mechanics topics and few design projects include the design of fluid systems. In addition, the results also suggest that the organization of the group design projects needs to be improved to better develop the students' teamwork skill.

Table 2 reveals the student perceptions of the industry importance of the listed skills and topics. From that table it can be seen that the students highly valued the influence of knowledge base of solid mechanics and manufacturing on their careers and ranked the leadership skill and CAD/CAE experience with the least industry importance. These results will be brought to our industry partners to find out the most wanted employability skills, according to which the course structure will be further modified.

Table 3 links the student evaluation results on the course goals (Table 1) with the industry importance (Table 2) to measure student satisfaction in this design course, in which the topics and skills are reordered according to their ranks in the industry importance survey. From that table it can be seen that most skills and knowledge of topics that the students considered important were evidently improved through this course. The only exception is the teamwork skill. The students considered that skill the third most important in industry but the growth of that skill only ranked 9th after completing the course. It is once again suggested that further measures need to be taken to fully develop the students' teamwork skill.

Table 4. Ranking of student perceptions on industry importance of skills and knowledge and their corresponding growths

Ranking	Skills/Topics	Growth
1	Solid mechanics (2.89)	0.61(2nd)
2	Manufacturing (2.93)	0.5 (3rd)
3	Teamwork (3.09)	0.27 (9th)
4	Communication (3.20)	0.47 (4th)
5	Management (3.55)	0.64 (1st)
6	Problem solving (3.64)	0.46 (5th)
7	Organization (3.82)	0.3 (8th)
8	Fluid mechanics (4.16)	0.14 (10th)
9	Leadership (4.23)	0.44 (6th)
10	CAD/CAE (4.45)	0.36 (7th)

5.2 Impact on ABET

This course has a broad impact on ABET educational objectives, which has also been verified through this survey. As can be seen from Table 4, the students agreed that this design course helped them to achieve 10 out of the 11 ABET outcomes (with an overall score above 4 out of 5). The only ABET outcome that received a score below to 4 is the criteria j): a knowledge of

contemporary issues. This fact that the students did not feel much improvement on their knowledge of contemporary issues suggests the teacher to introduce more contemporary issues in engineering and design into the class to fill this theory-practice gap.

The overall final average for the fall 2016 class was 79.72%, with 27 out of 44 students scoring at or above 75% for the semester average. The overall performance breakdown for this class consisted of 23% A, 23% B, 43% C, and 11% D grades. Homework problems were used to evaluate ABET goals (a) and (e), and 42 out of 44 students scored at or above 75% for both goals. The team design project was used to evaluate ABET goals (b-d), and (g). Students' performance showed that all the 44 students passed the performance criteria (score ≥ 75%) for goals (b), (c), and (g), and 43 students passed the performance criteria for (d). Final exam was used to evaluate the ABET goal (k) and we have 30 students scored at or above 75% in the final exam. A quiz on engineering ethics conducted in classroom was used to evaluate the ABET goal (f) and all the students passed it with a score ≥ 75%. Finally, the presented questionnaire was used to evaluate ABET goals (h) and (j), we have 41 students passed the criteria for (h) and all 44 students passed that for (j). Results from the direct measures of the student performance agreed very well with the results obtained from this questionnaire (Tables 1-4) and once again confirmed that most ABET goals as well as the course goals were achieved through the renovation of this course.

6. Conclusions

A course assessment questionnaire was designed and used for assessing teaching and course quality of the Mechanical Systems Design course at MSU, in which a unique industry-tied and team-oriented education mode was implemented. The questionnaire comprehensively investigate the student perceptions on achievement of course goals, student outcomes, and impact on the ABET outcomes, based on which the effectiveness and efficiency of the teaching and education approach and the satisfaction level of the students on this course can be deduced. The student feedback were collected and studied. The results showed that most course goals were achieved and overall the students were satisfied with the renovated course and recognized the effectiveness of the team design projects in growing their knowledge bases and developing their employability skills. Adoption of this new survey design also advanced the course assessment to ascertain motivation, experience, and understanding of ABET outcomes. From the results, it is also suggested that the organization of the design projects should be improved to enable the students to function more effectively in their teams. More contemporary issues in engineering design should also be brought into the course syllabus.

References

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