AC 2007-2468: LEADING AND ASSESSING A FIRST-SEMESTER TEAM DESIGN PROJECT

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Leading and Assessing a First-Semester Team Design Project

Abstract

Students are known to be motivated by course activities that are relevant to their careers. Design projects offer this type of real-life experience. This paper describes implementation and assessment of a design project that was adapted to a first-semester course that included both biological and agricultural engineering (BAE) and agricultural technology management (ATM) students. The project provided opportunity for experiential learning that engaged students, provided essential problem solving and teamwork skills, and assessed their learning about the design process. Students prepared a functional layout design for one of the BAE/ATM student spaces within Seaton Hall. The development of the layout design followed the design process, culminating in a presentation to the client (Department Head) and other constituents. Students were assessed using self-assessment, assessment of the presentation, and a short-answer exam. Results were classified according to seven elements of the design process: 1) teamwork, 2) information gathering, 3) problem definition, 4) idea generation, 5) evaluation and decision making, 6) implementation, and 7) communication. Students appeared to learn in proportion to their perceived level of class emphasis in the problem definition element and the teamwork element. Higher levels of understanding were demonstrated in the communication element and the information gathering element despite a perceived lesser class emphasis. Further work is needed to control for student knowledge of the design process elements when entering the class.

Introduction

Engineering design and development of student design skills are receiving increased attention as critical elements in engineering education, countering the established trend of focusing on education of the engineering sciences[1]. Methods to teach the engineering process require a breadth of instructional methods, classroom environments, and assignment types. However, little research has been conducted to compare the effectiveness of these methods for engineering design instruction[1]. A recent study confirmed that students are motivated by classroom environments that incorporate interaction and discussion (particularly higher-GPA students) and hands-on activities (particularly lower-GPA students) and assignments that demonstrate a clear connection to their profession[6]. While there is no one "right way" to teach the design process, it is clear that the creative learning required for engineering design requires creative instructional methods. In addition, it is essential that these methods be assessed to enhance the understanding of strengths and weaknesses of various instructional methods[7].

The objectives of this study were (a) to assess student learning outcomes of the design process and (b) to provide feedback about the effectiveness of a first-year design project and supporting course activities in leading to those outcomes.

Course and Design Project Description

The class consisted of two lab sections with 22-23 students each. Characteristics of the class sections are summarized in Table 1. Teams were selected by an in-class process, whereby members of each team were selected to produce a diverse membership according to characteristics the class felt were important to the design project, such as Meyers-Briggs personality trait indicators, major, size of hometown (rural/urban), etc. To the extent possible, women students were clustered in teams, instead of being distributed among teams, so that, though "minority members" of the class as a whole, they would not be "minority members" of their teams. Eleven teams were assembled consisting of 3 to 5 members.

Table 1. Class characteristics.

	Total	ATM	BAE	Women	Minority	Teams
Tuesday Lab	22	9	13	5	0	6
Thursday Lab	23	9	14	1	0	5
Total	45	18	27	6	0	11

The design project task was to prepare a functional layout design for one of the student spaces in Seaton Hall, housing the BAE department. Eight options were provided, and each student team in each lab section selected one of these eight spaces (without duplication within a lab section). The selection of was design project spaces was ordered according to a class-determined ranking of the creativity exhibited in the outcome of an in-class team ice-breaking assignment.

The objectives of the design project were to (1) engage the student in a problem solving/design process, in which s/he identifies a problem, locates relevant information, develops and analyzes possible alternatives, and formulates and implements a solution; (2) provide a structured setting for the student to develop skills to function within and contribute to a multidisciplinary team; and (3) provide experience in communicating data and ideas effectively in both written and oral forms.

The development of the layout design followed a four-step design process[5]: (1) *Problem identification*, culminating in a report of current conditions and a description of constituent needs. (2) *Specification development*, culminating in the development of needs-based criteria (or specifications) for rating design options. (3) *Conceptual design*, culminating in the generation of design options, evaluation of options according to established criteria, and selection of a proposed design. (4) *Detailed design*, culminating in detailed layout, parts list, costs, and other considerations of the proposed design. The primary client for this project was the BAE Department Head, who expressed an interest in improving BAE/ATM student spaces.

At the end of the semester, each team presented their results in a 12-minute presentation followed by 3 minutes of questions from the clients, faculty, and class. The final written report followed the ASABE Annual Meeting technical paper format and included an executive summary/abstract, two pages of report-body text, references, a final parts list, a presentation-quality layout drawing, and appendices.

Assessment Methods

Student learning of the design process was assessed using a self-assessment survey, faculty assessment of the final presentation, and a short-answer exam.

Self assessment

The self assessment followed the "Team Design Skill Growth Survey" instrument developed by the Transferable Integrated Design Engineering Education (TIDEE) project[2,3,4]. The survey allows students to self-assess the class emphasis and personal growth achieved in each element of the TIDEE engineering design process. Thirty-two questions are distributed within seven element categories[3]: 1) teamwork, 2) information gathering, 3) problem definition, 4) idea generation, 5) evaluation and decision making, 6) implementation, and 7) communication. For each question, students rate the class emphasis from 1 ("did not discuss") to 5 ("major emphasis") and rate their personal growth from 1 ("I did not use this skill within this class") to 5 ("I experienced a tremendous growth and added many new skills"). The self assessment was administered at the end of the semester. Ratings for each question were averaged for the whole class or a specific demographic within the class (i.e., lab section or major) for analysis. All questions within a category were also averaged to yield averages for each of the seven elements.

Presentation assessment

Final presentations were assessed both by the instructor and the primary client (BAE Department Head). The questions are summarized in Table 2. Ratings were assigned ranging from 1 (very poor) to 10 (outstanding). Each question was classified into one of the seven design process elements used in the self-assessment survey[3]. Scores from instructor and client were averaged for each question. For elements with more than one question, the average score for each question was averaged to yield an average score for each element.

Table 2. Presentation assessment categories and questions.

Design Process Element	Question
1-Teamwork	Solution demonstrates collaborative team effort
2-Information gathering	Research was used to help describe the problem
3-Problem definition	Design specifications were used to guide solution
5-Evaluation and decision making	Systematic process was used to select final design
5-Evaluation and decision making	Overall systematic design process was followed
7-Communication	Oral presentation was well developed
7-Communication	Presentation graphics were clear and effectives

Short-answer assessment

A short-answer assessment survey was developed to test student understanding of the design process elements. The questions used are summarized in Table 3. A single question was used as an indicator of understanding of each of five (out of seven) design process elements used in the self-assessment survey[3]. Student answers to each question were rated by the instructor using a simple 5-point scale: 1 (no understanding demonstrated), 2 (vague understanding), 3 (some understanding), 4 (moderate understanding), and 5 (clear understanding). Ratings were averaged for each question, yielding a single average score for each element.

Table 3. Short-answer assessment categories and questions.

Design Process Element	Question
(none-General understanding)	List the steps of the design process.
1-Teamwork	Recall your project team, and list the 4-letter MBTI of one other member of your team with different traits than your own. For one of the letters that is different, describe the challenge(s) posed by that difference. Describe one action you took, if any, to minimize the impact of that difference.
2-Information gathering	State one method of research that you used in your design project. List one other source that might have provided "better" information, and explain why you think it would be better.
3-Problem definition	Why is "problem definition" critical to development of an appropriate design?
4-Idea generation	List three actions you used in your group or that you could have used to encourage new-idea generation within the brainstorming process.
5-Evaluation and decision making	At the end of your design presentation, you tell your audience that your design has "met the goals of the problem definition statement." How could you prove this to your audience?

Results and Discussion

Self assessment

Student responses to the Team Design Skill Growth Survey indicated mid-level responses to all categories (Table 4). Responses indicated that problem definition and teamwork were significant emphasis in the class (rating near 4) whereas information gathering and communication were given some emphasis (rating near 3). Personal growth was also rated highest in these categories, with all elements being scored as achieving some growth with a few new skills (rating near 3).

Table 4. Self assessment results (mean ± standard deviation of all individual responses in element, n=45). Class emphasis: 1 (did not discuss) – 5 (major emphasis). Personal growth: 1 (skill not used in class) – 5 (tremendous growth, many new skills).

Design Process Element	Class Emphasis	Personal Growth
1-Teamwork	3.9±0.9	3.2±0.8
2-Information gathering	3.2±1.1	2.8±1.0
3-Problem definition	4.1±1.1	3.3±0.8
4-Idea generation	3.3±1.1	2.9±0.9
5-Evaluation and decision making	3.8±1.1	3.1±1.0
6-Implementation	3.6±1.0	3.1±1.1
7-Communication	3.2±1.3	2.8±1.1

Presentation assessment

Student presentations were rated highly in all elements (Table 5). Class time was devoted to discussion of a basic communications model (four elements: communicator, receiver, barriers, and feedback) and presentation organization, with specific emphasis and guidance on the project presentation. Several hours of lab time was provided for teams to work on presentations with instructor feedback. The strong results from the presentations might indicate that these strategies were successful in producing high-quality presentations. However, no controls were used to account for understanding of the communications process prior to entering the class. In addition, a good presentation product does not necessarily indicate learning of the communications process. In the future, a pretest/posttest approach could be used to tease out these differences.

Table 5. Presentation assessment results (mean ± standard deviation of all individual team ratings in element, n=11). Rating scale: 1 (very poor) – 10 (outstanding).

Design Process Element	Rating
1-Teamwork	9.4±0.4
2-Information gathering	9.0±0.5
3-Problem definition	8.9±0.7
4-Idea generation	N/A
5-Evaluation and decision making	8.9±0.6
6-Implementation	N/A
7-Communication	9.0±0.7

<u>Short-answer assessment</u>

The short-answer assessment tool indicated student learning ranging from "vague understanding" (rating of 2) to "some understanding" (rating of 3) with standard deviations of approximately one rating unit (Table 6). Problem definition rated the highest, with a mean approaching 3 ("some understanding") and the one-standard-deviation level approaching 4 ("moderate understanding"). As the first step of the design process and a step that was reiterated regularly throughout the design process, it is understandable that students would have achieved the greatest competency in this element.

Other elements were closer in rating to 2 ("vague understanding"), apparently indicating that learning was still in its early stages for these students. For example, although portions of several classes and labs were dedicated to the topic of teamwork, through in-class exercises, readings, presentations, and discussion, it appears that some basic elements of teamwork were elusive and to the students. Also, although a 3-hour lab class was dedicated to hands-on use of library database and Internet search tools, this activity did not carry over well to research related to the project or to clear student understanding of the information-gathering process.

Table 6. Short-answer assessment results (mean ± standard deviation of all individual ratings in element, n=45). Rating scale: 1 (no understanding) – 5 (clear understanding).

Design Process Element	Rating
1-Teamwork	2.1±1.0
2-Information gathering	2.2±0.8
3-Problem definition	2.9±0.8
4-Idea generation	2.2±1.1
5-Evaluation and decision making	2.1±0.9
6-Implementation	N/A
7-Communication	N/A

Summary

Each assessment tool has limitations in assessing the complex student-learning process as related to a specific class, design project, and set of students. As such, a global assessment using all the tools was undertaken. A summary of rankings of the three assessment tools used in this study is presented in Table 7.

Table 7. Summary results: Ranking of element scores for each assessment tool.

	Self assessment			
Design Process Element	Class Emphasis	Personal Growth	Presentation	Short-answer
1-Teamwork	2	2	1	4
2-Information gathering	6	6	2	2
3-Problem definition	1	1	4	1
4-Idea generation	5	5	--	2
5-Evaluation and decision making	3	3	4	4
6-Implementation	4	3	--	--
7-Communication	6	6	2	--

The self assessment and short-answer assessment agreed that problem definition element demonstrated the greatest level of understanding in this class. Also highly rated by the self assessment was the teamwork element, in agreement with the presentation assessment. In each case, students assessed their own growth consistent with the class emphasis and an independent measure of student learning.

The communication element and the information gathering element were rated as tied for the lowest class emphasis. This was consistent with the self-reported personal growth, but not consistent with high rankings in both the presentation and short-answer assessments. This could indicate that students entered the class with a reasonable understanding of communications and information gathering, and that the class activities were not substantial enough to add to this understanding. Improvements to the assessment methodology should be able to capture student knowledge entering the class with a "pretest" approach. The recommendation of the TIDEE project is to administer the Team Design Skill Growth Survey both mid-semester and at semester end to better assess growth during the class[2,3,4].

Conclusions

Student learning was documented for seven skill elements needed in the design process. Students appeared to learn in proportion to their perception of greater class emphasis in the problem definition element and the teamwork element. Higher levels of understanding were demonstrated in the communication element and the information gathering element despite a perceived lesser class emphasis.

These results yielded important instructor feedback about how class emphasis aligned with student learning in each design element. Future classes and design projects will address shortcomings in specific design skill elements by enhancing instruction, in-class activities, and project activities.

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