Student Evaluation of the Thermal/Fluids Design Experience

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Abstract

The paper details on-going course development and improvement in a senior level heat transfer laboratory incorporating a design experience. The heat transfer laboratory includes eight (8) laboratory exercises and concludes with a seven week thermal design project. The project is chosen to include multiple aspects of thermal design and to incorporate the tools utilized in the earlier laboratory exercises. The goal of the project is to provide the students with a thermal engineering experience in which they design, build, test and report on their work. Feedback to students is provided during weekly meetings with the instructional staff, a design competition and through grading of the written project report. Students were given anonymous pre and post-surveys to obtain their expectations and evaluations of the thermal design experience. The purpose of this exercise was not to evaluate the learning objectives specifically, but to measure the students' perception of the project. Three factors were targeted specifically; the students' confidence in their technical skills, group skills and leadership, and whether students found the project engaging. Those survey results are analyzed and it can be concluded that the students do gain a measurable increase in their design skills and in their ability to function as a team member.

I. Introduction

A thermal/fluids design experience is essential for a complete mechanical engineering educational experience and is also a mechanical engineering program requirement of the Engineering Criteria 2000 [ABET, 2000]. This experience should include design, build, test, report and feedback aspects for maximum educational benefit [Kolb, 1984]. A program to meet these requirements has been successfully implemented at Michigan State University as a portion of the senior level heat transfer laboratory course. Details of the thermal design projects were presented by Somerton et al. [1999]. This work continues the development of the thermal design experience by obtaining and analyzing the students' evaluation of the projects.

To fulfill the intent of the Engineering Criteria 2000, students must be provided opportunities in which they can successfully complete thermal design challenges [ABET, 2000]. The students must also feel that the experience is sufficiently challenging in order to develop confidence in their skills and knowledge base. This is a delicate balance to maintain. Successful project

completion reinforces their thermal design knowledge but also provides them with the confidence to implement their skills. Students were given anonymous surveys before and after the project as a means to evaluate the impact of the thermal design experience at Michigan State University from the students' perspective. This paper presents the survey results and focuses on the implementation of those results as a means to continually improve the students' thermal design experience.

II. Design Project Description

The student design groups were required to design a water heater utilizing twelve (12) birthday candles as an energy source. The project goal was to heat 400 milliliters of water in a 1 liter beaker to as high a temperature as possible. The device could have maximum dimensions of 5" x 4¼" X 12" and had to be inflammable. This project is one of five (5) different projects utilized for the design phase of the heat transfer laboratory. The projects are selected so that the students are required to utilize a variety of skills and tools developed during the heat transfer class and laboratory exercises.

The project culminates in a design competition in which each design group is given two (2) minutes to heat the water with the birthday candle energy source. The student teams compete based on weight of the device, cost of the construction materials utilized, and quantity of energy ($mc_p\Delta T$) delivered to the water. Points were assigned based on ranking (20 for first, 19 for second, etc.). The points awarded for energy delivered were doubled to enhance the importance of that design consideration.

III. Pre and Post Surveys

Anonymous surveys were provided to the students when the design project was assigned and during the design competition. The surveys targeted three specific areas: student perception of educational accomplishment (EA), student enjoyment of the design project (SE), and assessment of design team experience (TE). Two additional questions were asked on the post project survey to obtain the students' evaluation of the clarity of the competition rules and the effectiveness of the weekly meetings with the instructional staff.

The post-survey questions are presented in Table 1. All questions provided for a numerical response ranging from 0 to 10. The range varied from a strong negative response at 0, a neutral response at 5 and a strong positive response at 10. The strong negative and strong positive responses are provided in Table 1. The pre-survey questions were identical with the tense of the question adjusted appropriately. Questions 11 and 12 were not present on the pre-survey.

Table 1. Post-survey questions with response range and area of interest.

	Post-Survey Questions	Response Range	Area
1	If at my first job I was asked to work on a project involving thermal design I feel I would _____ at the task.	0 – Fail 10 - Succeed	EA
2	I learned _____ than the normal labs from the design project.	0 – Much less, 10 – Much more	EA
3	I enjoyed the design project _____.	0 – Not at all, 10 – Completely	SE
4	My team to performed _____.	0 – Worse than individuals, 10 – As a synergistic group.	TE
5	I learned_____ about managing a project.	0 – Nothing, 10 – Everything from leadership to project management	TE
6	I feel that the team building experiment explained _____ regarding the team aspects of the project.	0 – Nothing at all, 10 - Everything	TE
7	I would give my team members a grade of _____.	0 to 4.0 by 0.5 increments	TE
8	Compared to the regular laboratory exercises, I learned _____ from the design project.	0 – Fail, 10 - Succeed	EA
9	I used ____ of the information from earlier labs and classes.	0 – None, 10 – Multiple sources	EA
10	The design competition was _____.	0 – A waste of time, 10 – Exciting and motivating	SE
11	Weekly meetings with the instructional staff were _____	0 – A waste of time, 10 – Informational and kept us on track.	
12	The project requirements and the competition rules were _____.	0 – Completely unclear, 10 – Crystal clear.	

Multiple questions were asked in each target area (SE, EA, TE) to test for uniformity of the responses. The survey instructions also asked students to write any additional comments regarding the design project on the back of the survey.

IV. Survey results and discussion.

The results of the survey were tabulated and analyzed. The results for the entire survey are presented in Figure 1. The error bars in the figure represent the standard deviation of each response. The standard deviation on each question remained relatively unchanged between the pre and post-surveys and most variation was of the magnitude of 2. Note that the highest possible response to question 7 was 4.0.

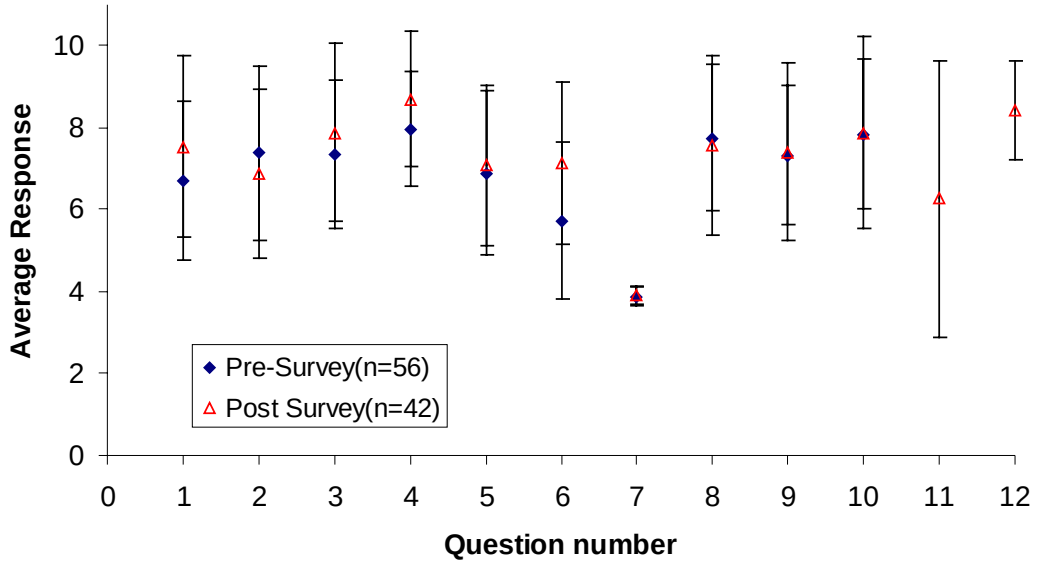

Figure 1. Pre and post-survey results shown with standard deviation of the responses.

Improvements in the average response are shown for questions 1,3,4, and 6. Flat responses or decreases in the average student response are shown for questions 2,5,7,8 9 and 10. It is also important to note that in each case the responses are greater than 5 so that even in the case of a flat or declining response, the average student still rated the experience as positive. It is important to note that with the variation of the responses that none of the changes are statistically significant, however, trends do appear in the responses to many of the questions and histograms of those questions will be presented and discussed. Each target area will be reviewed next and inferences will be drawn from the trends.

IVa. Educational accomplishment.

Questions 1, 2, 8 and 9 targeted the learning process and the educational value of the design project. Question 1 (Figure 2) addressed the students' confidence in their thermal design skills and knowledge. The histogram shows an improvement in the results for the post-survey, most notably the number of students responding with a strong positive (10) reply. The average response from the surveys improved from 6.7 to 7.5. This is indicative that the project improved the students' confidence level when faced with a thermal design task.

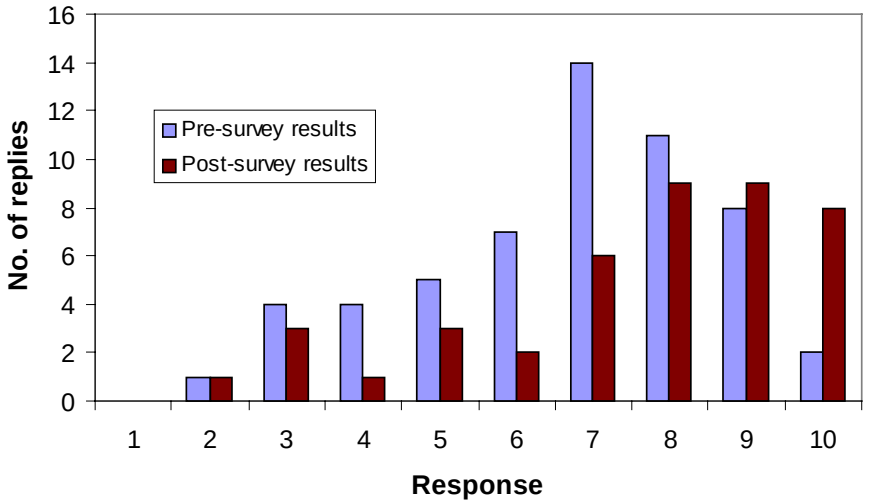

Figure 2. Survey results for question 1: Expected future job performance.

The second and eighth question addressed the students' perception of the quality of learning obtained from the design project compared to the regular laboratory exercises. Both questions show an over all positive average response (>5), however, the average and the overall trend appears to decrease in the post-survey results. This indicates that the project did not meet students' expectations or that the educational goals and outcomes were not clearly explained to the students and then met.

The results from question 9 were also unchanged between the pre and post surveys. Question 9 addressed the use of information from earlier laboratory exercises and from previous classes. The design projects are chosen to incorporate skills and knowledge previously acquired. The average response to this question is 7.4 which is clearly positive (>5) and indicates that the majority of students feel that the laboratory exercises helped prepare them for the design tasks.

The education assessment results from the survey are positive overall. The average student response to all four questions is 7.3 in both the pre and post-surveys. Overall student confidence was clearly improved while the other educational assessments were met but did not exceed student expectations.

IVb. Student enjoyment of the design project.

Two questions were asked to evaluate the students' enjoyment of the design project. While student enjoyment of the process is not required, learning can be greatly improved if students are interested and engaged in the process [Wankat and Oreovicz, 1993]. Question 3 addressed the students' enjoyment of the design project specifically and question 10 addressed the design competition as a source of motivation. Figures 3 and 4 contain histograms of the results from

questions 3 and 10 respectively.

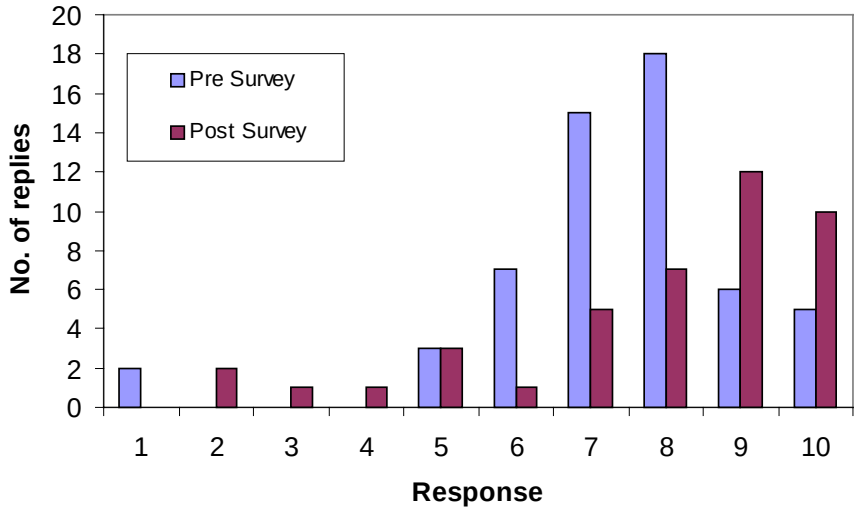

Figure 3. Survey results for question 3: Enjoyment of the design project.

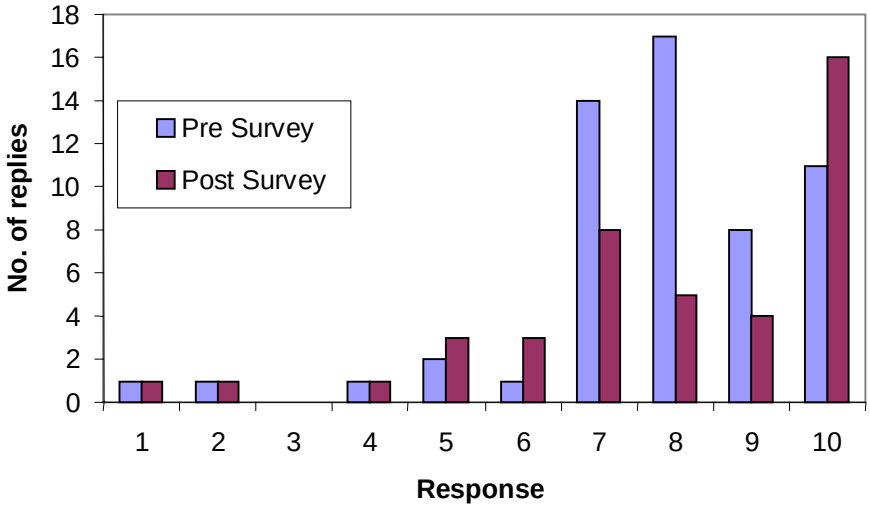

Figure 4. Survey results for question 10: Motivational value of the design competition.

Both Figures 3 and 4 show improvement in the post-survey results indicating that the students did enjoy the design project as a whole and the design competition in particular. Results from both pre and post-surveys were positive (>5) indicating student satisfaction with the design project.

IVc. Team work experience.

Most engineering tasks now involve teams of engineers to complete and cooperative working skills are essential [McKeachie, 1969]. Educational objectives tend toward individual performance on exams and homework. It was therefor decided to obtain the students' evaluation of the design team experience. Questions 4,5,6, and 7 addressed various aspects of the project team. Question 4 addressed the team's performance. Question 5 targeted project management. A team building laboratory experiment is conducted during the regular laboratory sessions. Question 6 asked the students to evaluate the usefulness of that experience. Finally, question 7 asked the students to grade their fellow teammates.

Figure 5 contains the survey results from question 4. This clearly indicates that the average students' expectation of the team's performance were met and exceeded. The average response increased from 8 to 8.6. The number of responses of strong agreement (10) doubled from the pre to the post survey and there is only one post survey response of less than 6.

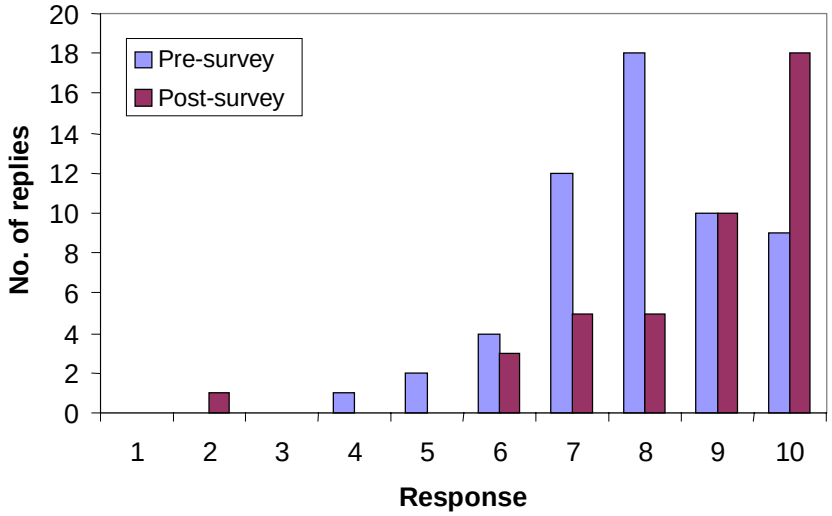

Figure 5. Survey results for question 4: Team performance.

Question 5 targeted project management skills utilized for the design project. These results show an average positive (>5) response of 7 for the pre and post surveys. The trend appeared to be relatively unchanged which is interpreted as indicating that the students felt that the project met expectations for development of group skills.

Figure 6 presents the results from question 6 which was targeted at the usefulness of the team building experiment conducted during the regular laboratory exercises. The team building experiment focused on emphasizing free transfer of ideas between team members, delegation of responsibilities, and importance of individual contribution to group success. This result shows the

clearest improvement of any of the results presented. This indicative that although at the time of the experiment the group skills may not have been fully appreciated or understood, the design project allowed for ample use of the team work skills and that the aspects of the team building experiment were directly applicable to an engineering task.

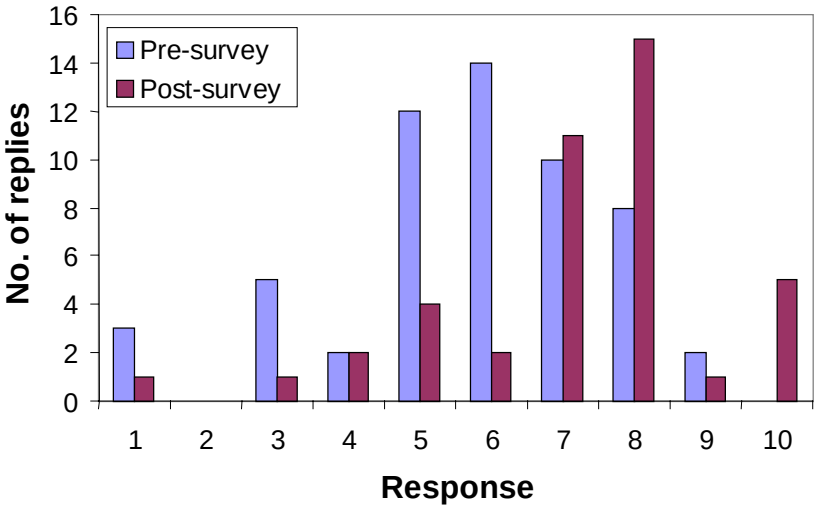

Figure 6. Survey results for question 6: Evaluation of the team building experiment.

The last of the comparative results to be presented is the students' evaluation of their teammates by assigning them a grade. The average response for this question was 3.9 out of a possible 4.0 for both the pre and post-surveys. This is clearly a positive response and supports the other teamwork data.

IVd. Instructional staff and project rules.

The last two questions (11 and 12) on the post-survey dealt with the interactions with the instructional staff and the design project rules and requirements. The average result of question 11 regarding the instructional staff was 6.4 with a standard deviation of 3.6 clearly indicating a wide range of responses. Figure 7 contains a histogram of these results that indicate a reasonably flat response with 3 or 4 apparent peaks at approximately 1,3, 6 and 10. There were 4 staff members on the instructional team. This seems to indicate that the students' experience varied with staff member. Students' grades were also evaluated as a function of supervising staff member based on this result. This showed that the staff member supervising the students with the highest average grade also was supervising the most student teams. This could explain the large peak at 10 in Figure 7. This result indicates that the students' experience with the instructional staff requires homogenization in the interest of fairness and quality.

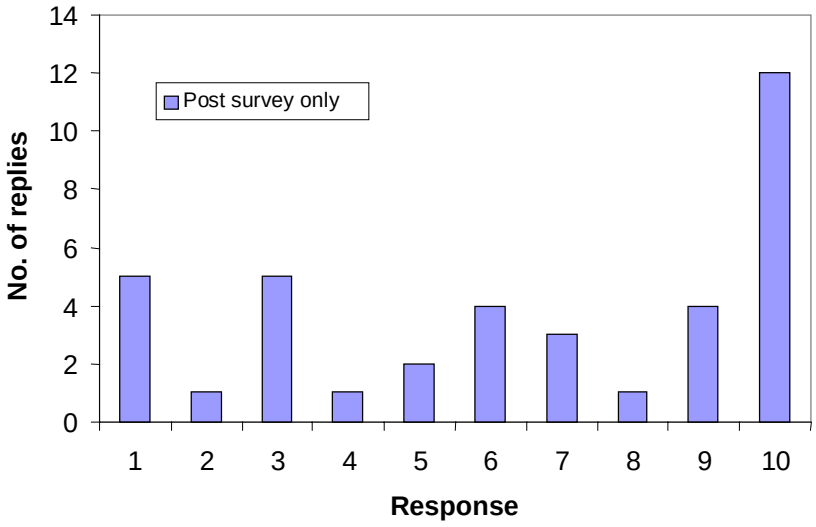

Figure 7. Survey results for question 11: Interaction with the instructional staff.

The clarity of the project and competition rules was addressed in question 12. The average response was 8.4 with only 1 response below 7. This clearly indicates that the project requirements and rules were well communicated to and understood by the student teams.

V. Conclusions, recommendations, and course modifications.

The following conclusions are drawn from a review of the survey results. Three recommendations regarding the course are suggested based on these conclusions.

The average student response on the educational assessment questions shows a flat or slightly negative trend on the post-survey. The average result is positive (>5), however this result will be used to review the educational goals. The results indicated that the students did enjoy the design project and the design competition. This information indicates that the flat result in the educational assessment questions is not the result of student indifference. It is proposed that the educational outcomes of the design project were not clearly explained to the students. It is recommended that the educational targets of the project be clearly outlined and presented to the student design teams at the beginning of the design project.

The second conclusion is that the students prefer the controlled environment of the regular laboratory exercises. The design project is inherently less controlled by the instructional staff, than the regular laboratory exercises. It is recommended that the variability inherent to the project be maintained and emphasized. This will provide a more realistic reflection of a real design task and will help prepare the students for assuming responsibility. The instructional staff needs also to carefully watch to intervene with any groups that do become lost or frozen by indecision that may develop in the uncontrolled environment.

The third conclusion is that the student teams' interaction with the instructional staff needs to be homogenized. This insures fairness and uniform access to project information and help if required. This is more difficult with a rotating body of graduate assistants, but could be addressed with staff training and weekly meetings. One other possibility would be to allow student groups access to different staff members on a rotating basis to insure fairness.

The final conclusion drawn from the survey results is that the thermal/fluids design experience at Michigan State University is a general success. It helps provide students with confidence in their skills and knowledge base and provides an opportunity for students to function in a team environment. The weekly meetings with the instructional staff and the design competition provide feedback to the students and allow for instructional input in the design process to enhance learning opportunities. The project also assists in meeting ABET criteria while providing students with a design and build thermal/fluids engineering task.

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