AC 2011-814: ASSESSING ENGINEERING STUDENT ATTITUDES ABOUT COGNITION DUE TO PROJECT-BASED CURRICULUM

Donald Plumlee, Boise State University

Dr. Plumlee is certified as a Professional Engineer in the state of Idaho. He has spent the last ten years establishing the Ceramic MEMS laboratory at Boise State University. Dr. Plumlee is involved in numerous projects developing micro-electro-mechanical devices in LTCC including an Ion Mobility Spectrometer and microfluidic/chemical micro-propulsion devices funded by NASA. Prior to arriving at Boise State University, Dr. Plumlee worked for Lockheed Martin Astronautics as a Mechanical Designer on structural airframe components for several aerospace vehicles. He developed and improved manufacturing processes for the Atlas/Centaur rocket program, managed the production implementation of the J-2 rocket program, and created the designs for structural/propulsion/electrical systems in both the Atlas/Centaur and J-2 programs. Dr. Plumlee also worked at NASA's Marshall Space Flight Center as an engineer in the Propulsion Laboratory. In practicing the engineering profession as a conduit for preparing future generations of engineers, he wants to provide students with both a technical competency and the ability to understand and respect the trust that is invested in us by society. As an educator, he guides future engineers through a learning process that develops a strong technical foundation and the ability to independently cultivate further technical competencies. He is particularly interested in advocating for project-oriented engineering education. He and a research team at Boise State University is currently participating in a project focused on encouraging the adoption of project-based techniques.

Assessing Engineering Student Attitudes about Cognition Due to Project-Based Curriculum:

Donald Plumlee, Assistant Professor of Mechanical & Biomedical Engineering at Boise State University

I. Introduction

In recent years, a substantial amount of research has been presented on project-based learning for educating engineers.[1, 2] It has been observed that this approach fosters a deeper learning and understanding of engineering concepts as opposed to the traditional lecture-based course structure. In addition, research has documented the prevalence of "Ill-Structured" problems that engineers face in their professional lives.[3] Posing these types of "problems" in an academic environment would better prepare students for higher achievement after graduation, but adoption is sporadic.

A current active research area in engineering education is based on understanding and overcoming the hurdles in transforming from a lecture-based curriculum to a more project-centered curriculum. Even knowing the benefits of project-based approaches, engineering faculty must overcome barriers such as limited time, assessment methods, accreditation requirements, knowledge of unfamiliar techniques and student resistance. Student resistance was identified as part of an initial inquiry into these barriers. According to Evans, high achieving learners regardless of discipline typically possess three characteristics.[4] First, high level learners think deeply about the subject matter rather than superficial memorization of concepts. Secondly, they are adaptive in their learning process rather than repeating or relying on a single method. Finally, high level learners have an attitude that reflects a "Need for Cognition" or a willingness to put forth cognitive effort. It is typically assumed that a project-based curriculum in engineering education promotes these characteristics and encourages higher level-learning. In fact, for project-based learning to be widely adopted, there must be a willingness within the student body to modify their traditional role within the curriculum.

Anecdotal evidence suggests that attitudes towards higher level learning vary among engineering students. Many engineering students appear to be more comfortable in rigid structured learning environments, while some students seem to prefer more creative expression. Improving each student's comfort with the "Ill-Structured" problems faced in professional careers should be a goal of project-based education, but may also be a hurdle towards effective teaching. In this study, a group of engineering students were surveyed using a modified version of the "Need for Cognition" study to evaluate engineering student attitudes towards using cognitive tools.[5] The results of this survey are presented in this paper along with several conclusions regarding the effect of project-based curriculum on student attitudes.

II. Class Description

This study involves the investigation of a senior level mechanical engineering class of approximately 38 students. The students were not identified demographically, but the class was composed of a wide variety of experience levels ranging from traditional students that transitioned directly from high school to students with multiple years of work experience. The course was presented as a study in applying thermal and fluidic concepts in a system design format. The course included five different projects throughout the semester, each incorporating a variety of concepts presented initially in previous courses. The students were graded on a rubric with categories such as teamwork, functional task breakdown, governing equations, solution method and presentation. The projects were successively more open-ended in terms of defined project requirements and the final project was a design and fabrication task of developing a small wind-turbine. The class lecture time was spent reviewing concepts, discussing projects and learning application related concepts including economic analysis and project management. The projects were divided into 3 group and 2 individual assignments.

III. Survey

The survey created for this study was a modified version of the "Need for Cognition" survey developed by Petty and Cacioppo.[5, 6] The modified version of the survey consisted of the original 18 questions with an additional 5 questions added at the end for a total of 23 questions. Each question response was a rating from 1 for strongly disagree to a maximum of 5 for strongly agree. The modified survey is presented in Table 1.

Table 1: Modified "Need for Cognition" Survey Questions. Each question was rated on a 1-5 scale (5=agree, 1=disagree)

1.	I would prefer complex to simple problems.
2.	I like to have the responsibility of handling a situation that requires a lot of thinking.
3.	Thinking is not my idea of fun.
4.	I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.
5.	I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.
6.	I find satisfaction in deliberating hard and for long hours.
7.	I only think as hard as I have to.
8.	I prefer to think about small, daily projects to long-term ones.
9.	I like tasks that require little thought once I've learned them.
10.	The idea of relying on thought to make my way to the top appeals to me.
11.	I really enjoy a task that involves coming up with new solutions to problems.
12.	Learning new ways to think doesn't excite me very much.
13.	I prefer my life to be filled with puzzles that I must solve.
14.	The notion of thinking abstractly is appealing to me.
15.	I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16.	I feel relief rather than satisfaction after completing a task that required a lot of mental effort
17.	It's enough for me that something gets the job done; I don't care how or why it works.
18.	I usually end up deliberating about issues even when they do not affect me personally.
19.	Complex problems are easier to work in a single focused effort.
20.	I like to plan my solution approach at the start of a complex problem.
21.	I enjoy hard problems that have a specific solution that can be verified.
22.	Sometimes I feel frustrated about not knowing the next step in a solution.
23.	I prefer a problem with fewer given constraints.

The survey questions were administered on the third week of class (September 2010) and again on the last week of class (December 2010). The survey data was collected anonymously from the students but each student was asked to provide a self-assigned tracking number that they could remember (last 4 digits of phone number). This tracking number was used to correlate longitudinal changes in the perceived attitudes of individual students as a result of exposure to project-based assignments. This result was combined with overall group averages to provide a snapshot of student attitudes before and after a project-based course.

IV. Results

A series of approaches was used in approaching the survey data collected. The overall group average results for "before" the class and "after" the class are presented in Figure 1. These results include all responses collected for both surveys including those with incorrect or missing tracking numbers. In each graph presented in this study, the "before" results correspond to the survey conducted in September 2010 while the "after" results correspond to the December 2010 survey.

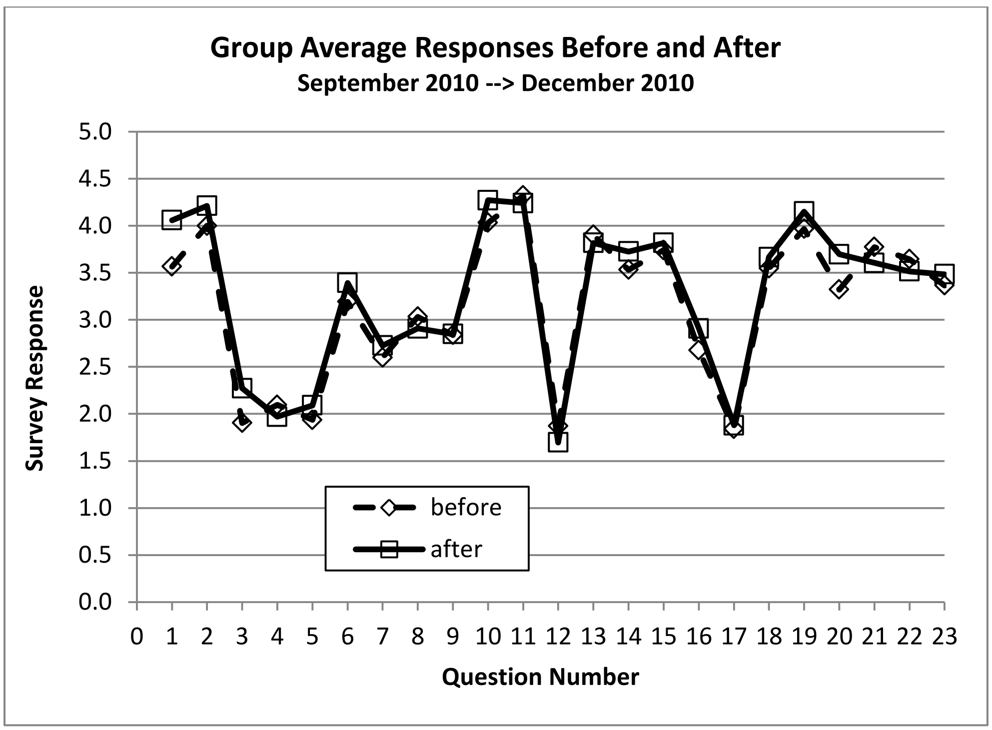

Figure 1: Group average results presented for each question. These results are provided both before and after the project-based learning course.

The average student responses indicate an overall comfort or even desire to use cognition in the course of solving problems. The strongest responses were seen in questions 2, 10, 11, 12, and 17. Each of these responses indicates a desire to use or rely on cognitive processes as a personal characteristic.

In addition, there was a high degree of similarity between the "before" and "after" results as a group. The data for each question exhibited standard deviations ranging from 0.63 on question

10 to 1.37 on question 6. The data clearly follows a similar pattern throughout both surveys with minor differences showing up primarily in the questions that tended to have a more extreme answer. Some students may be less inclined to fully commit to answers that indicate strong feelings away from the median response. It appears that in most cases, the high results trended higher and the lower results trended lower in the “after” data as compared to the “before” data. This seems to indicate a stronger or more confident response on average in the “after” survey to questions such as 2 and 12. Question 2 which produced a high response, changed from an average of 4.00 to an average of 4.21. Question 12 which produced a low response, changed from an average of 1.90 to a lower average of 1.70. To better observe these changes, the change in average response “before” and “after” the course were plotted in Figure 2.

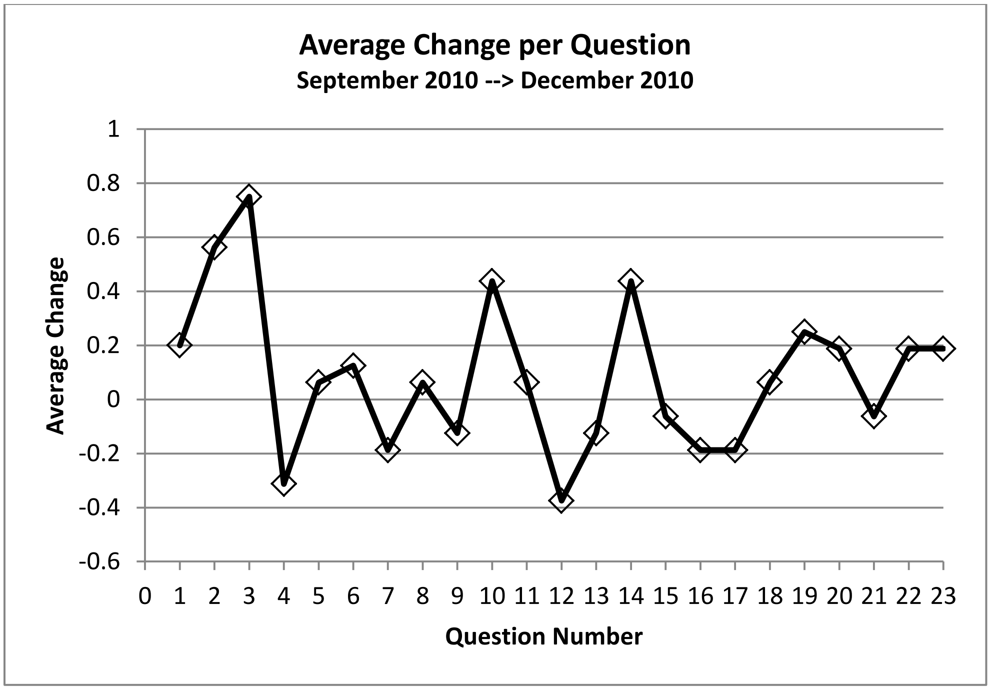

Figure 2: Change in average survey response for each question for responses recorded "before" and "after" the project-based course.

This data more clearly illustrates the questions exhibiting the largest overall changes in the average student response produced by the course. Ignoring questions falling in the range between ±0.2, the largest changes were observed in questions 2, 3, 4, 10, 12, 14 and 19. The response to question 3 increased over the span of the course which indicates that the students were less likely to see thinking as fun. In the other noted questions, the responses indicate more comfort and recognition in the need for cognitive processes. This result seems to indicate that the project based class produced a better recognition of the need for cognition while not necessarily seeing that usage as enjoyable.

These results are based on the entire group as an average for each question, which does not provide details on the change of individual students in the class. Using the tracking numbers described above, the data was sorted into individuals with data for both “before” and “after” responses that could be tracked. Due to missing or changed tracking numbers, the group of students being studied was reduced to 16 individuals. Within this group of students there were 6 individuals who exhibited significantly more change than the average and 4 students that exhibited significantly less change than the average. These new groups were denoted as "high changers" and "low changers". The average change in response for these high and low changers are compared to the group average in Figure 3.

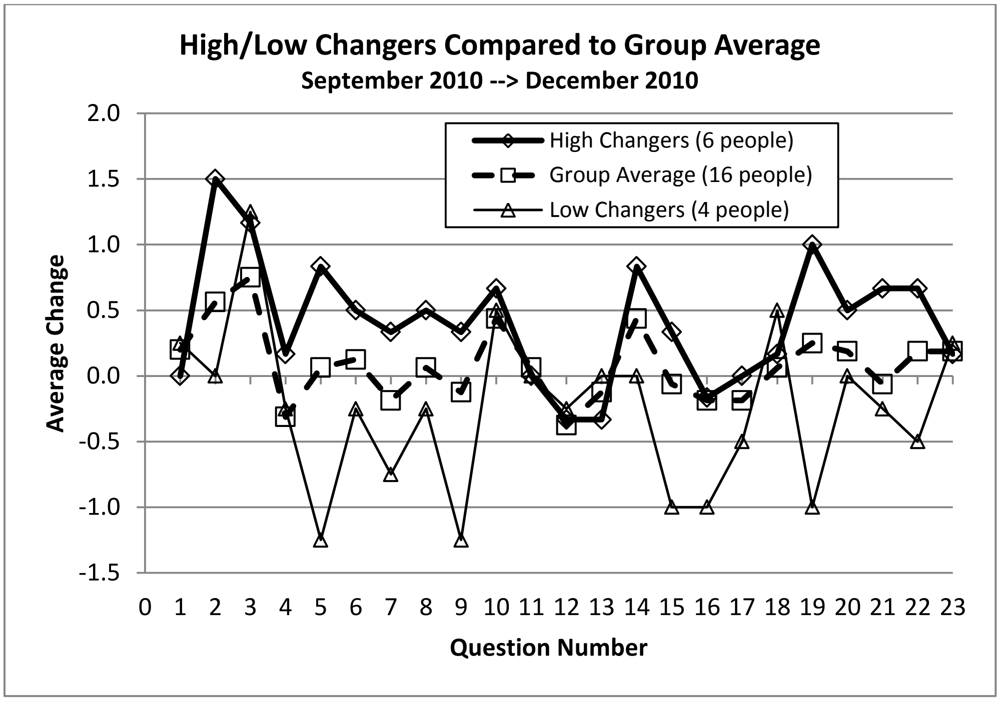

Figure 3: High and low changing students as compared to the group average.

The response data for high and low changers indicates a significant difference between the two groups of students and the average. The students that are high changers increased their responses in almost all categories with the exception of questions 12, 13 and 16. Lower responses to questions 12 and 16 indicate an increased comfort level with using mental effort. The low changers decreased in almost all responses. The small sample sizes of each of these two outlying groups make it more difficult to determine the significance of these results. In addition, overall change helps to identify those most affected due to the course, but does not effectively present the entire scenario. It is important to look at the initial starting point for both groups and how they changed relative to the entire group. In Figure 4, the survey responses of the high changing group are compared to the average "after" results of the entire group.

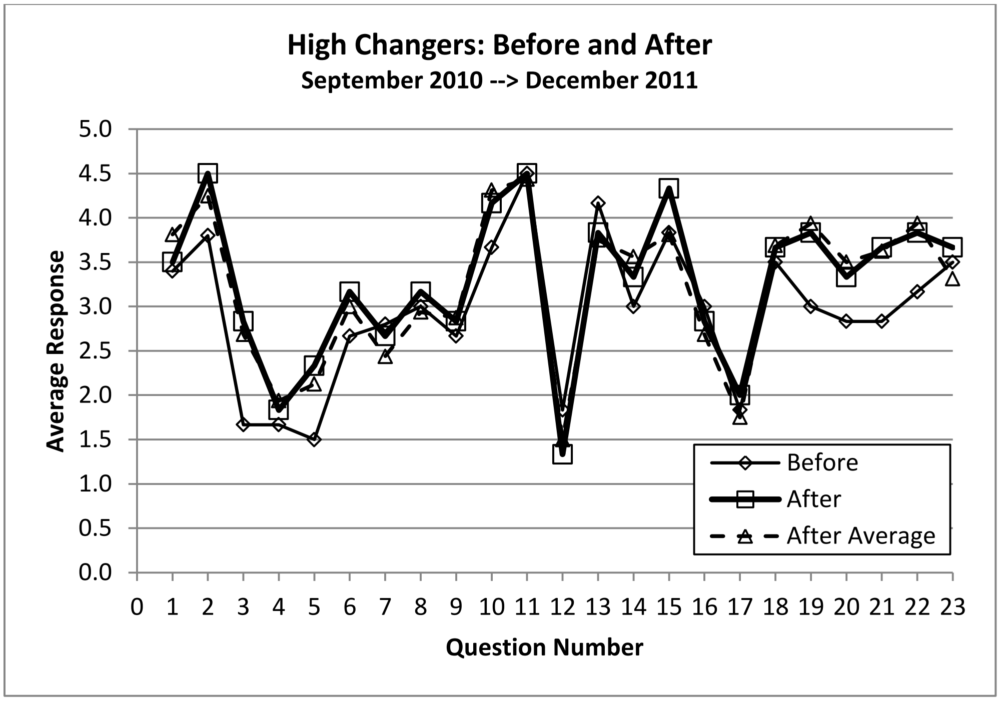

Figure 4: High changing student responses as compared to the group average

In this graph, the "before" responses for high changers are clearly lower than the "after" responses in several key areas including questions 2, 3, 5, 6 and 19-23. These questions indicate an initial lack of comfort with using cognition in this group of students. The "after" responses for the high changers are very similar to the overall "after" group average. This indicates these students may have started with some misconceptions and lower comfort level at the beginning, but were able attain a comfort level similar to the entire group at the end of the course. This result is backed up anecdotally in conversations with students in the class. Several students expressed concerns about the lack of structure in the problems and the inability to determine when they had completed the assignment. These same students showed tremendous growth in their comfort level through the course.

The low changing students are illustrated in Figure 5. These students exhibit very little difference between "before" and "after" results with the exception of question responses 5, 9, 15, 16, 19. Each of these response drops indicates an increased comfort level and interest in working with harder problems. The low changers start relatively high in their "before" responses and then drop in the "after" survey where a lower response indicates an increased comfort with cognition. These students likely have some understanding of the problem based learning environment, possibly as non-traditional students. For this group, the course seems to have had less overall effect with the exception of increasing the comfort level with using cognitive processes as part of the task. Many non-traditional students in this class have worked as technicians at a local electronics fabrication company, which may contribute to a limited desire for the investment of mental effort.

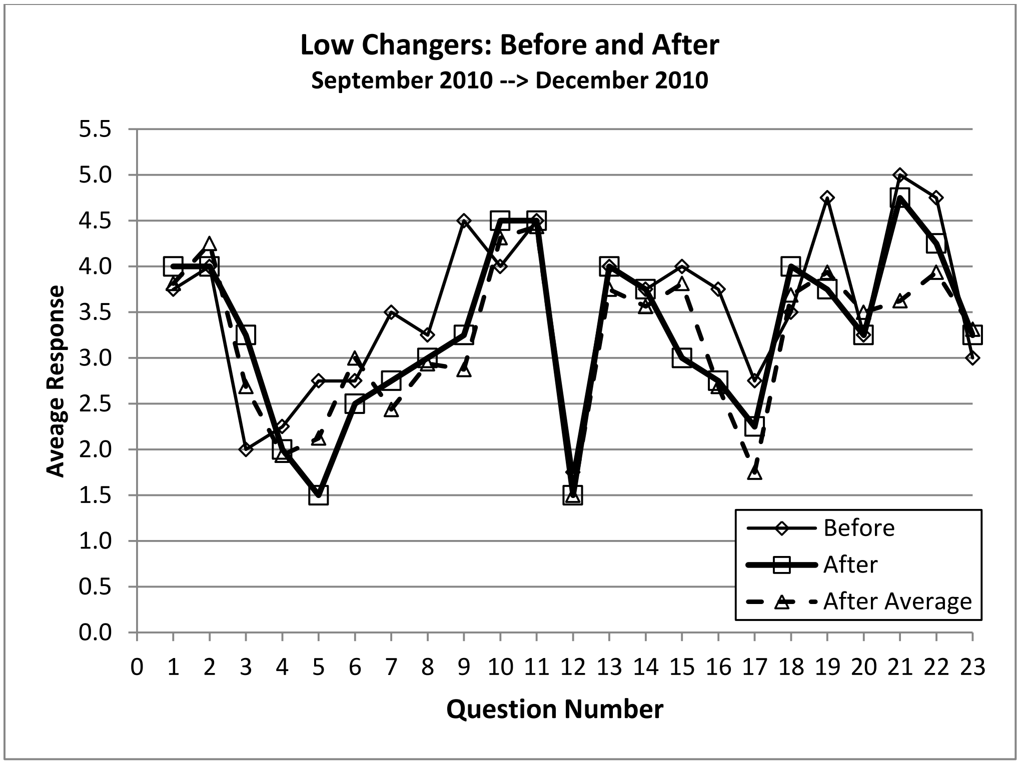

Figure 5: Low changing student responses as compared to the group average

V. Summary

A study was conducted to investigate changing engineering student attitudes after taking a project-based learning class. In this study, a senior mechanical engineering class was given a 23 question survey based on the "Need for Cognition" instrument. The student responses were tracked individually using a self-assigned code. The average student responses showed small variations in the question responses, typically in the direction of stronger responses. The stronger responses indicate an overall increase in comfort level with using cognitive tools in performing engineering problems. The results were presented in terms of change in group average response. The stronger responses again indicate more comfort and understanding about using cognitive tools over the duration of the course. A stronger response in question 3 indicates a reduction in student perception that "thinking is fun." This is coupled with a stronger response in recognition of deeper thinking as a necessary tool to be a good engineer. When analyzing the longitudinal aspects of the data, two groups were identified based on overall change between surveys. A higher change group of 6 students was found to have several areas of lower responses initially. This group reported higher response changes through the semester to produce results that matched the final overall group average. The lower changing group was initially high in several categories related to the need or interest in solving problems with cognitive tools. The lower change over the semester was related to reductions in these categories.

VI. Conclusions

The data presented in this work, indicates that student attitudes towards cognition can be affected by problem based learning. These students enter class with different comfort levels or knowledge of how they use cognition in their engineering coursework. This difference could be based on a varying life experiences or possibly learning styles. Regardless of initial response, the overall results at the end of the class seem to be more consistent across all the questions. The changes observed in the survey as a result of the problem-based curriculum almost always indicate that while not always seen as fun, the students attained an improved attitude towards applying cognitive tools to engineering tasks. In some cases, students were initially less comfortable with the new learning environment, but these students exhibited larger changes than the average student in the group. Based on the collected data, it appears that there is a positive effect on student's attitudes towards cognitive tools when exposed to a problem-based learning environment. This improved student attitude is critical in achieving deeper learning and preparing students for effective engineering careers.

VII. References:

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