# AC 2008-1647: AGILE EDUCATION: WHAT WE THOUGHT WE KNEW ABOUT OUR CLASSES, WHAT WE LEARNED, AND WHAT WE DID ABOUT IT

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# Agile Education: What We Thought We Knew About our Classes, What We Learned, and What We Did About It


## Abstract

In a continuing effort to improve a first-year design course, a team of faculty has evaluated a variety of learning modes over a two-year period by surveying both the student and faculty populations on the learning potential of each of these modes and on the degree to which each mode is interesting or engaging. Following the first year of the study, efforts were made to address learning modes which were rated low for both categories of learning potential and level of engagement. This paper presents the results of the survey administered in the second year and assesses the effectiveness of changes made to some learning modes. In addition to the student survey results, instructing faculty personal opinions of learning potential and level of engagement for each mode are included along with faculty predictions of how the students would respond from their learner's perspective. The data was used to establish how well we as educators know our students. Results were evaluated to determine if (a) our prediction for an activity makes a difference in how the students rate a learning mode for learning potential and level of engagement and (b) if any mismatch exists in what we think and what they rate. This work provides examples of the student and faculty surveys, proposes solutions, provides assessment to components and modes presently not hitting the mark, and discusses the results of the faculty opinion survey. The hope is that other educators may identify with these outcomes, use similar tests to judge their student population, and use the results to make helpful adjustments to course content.


## Introduction

As educators, much of what we formulate and choose to apply in the classroom with regard to learning activities is usually measured against the potential of each method to teach a concept. In many instances, whether or not the activity will engage the student is secondary to the primary objective –retention of the lesson. Of course, we would prefer to use activities that have a substantial level of engagement as well as a high learning potential but this simultaneous effect is not always possible. Even learning modes with high engagement levels are no guarantee that the experience will educate students in the most effective way. Therefore, for any course to evolve to its fullest potential, we must also assess each of the learning modes, or activities, used for its level of engagement as well as its potential for learning. The natural response to any educational assessment is to consider modifications in accordance with the feedback obtained.

The original research initiative, conducted by a team of faculty at Northeastern University established that our existing first-year design course format was effective from a learning assessment perspective. The course had passed through multiple iterations over an eight-year period, undergoing incremental changes with positive results[5]. It was then time to take a new look at the course. Subsequent research was conducted and presented at ASEE, in which the same team of faculty investigated whether or not high classroom engagement with a variety of learning activities equated to a significant amount of learning for the student. On the survey, the *engagement* element was defined for the students as follows: "The Interest portion is not merely about how fun the activity is compared to entertainment, but how engaging or interesting it is compared to other classroom teaching options." Similarly the concept of *learning value* was described as follows: "The learning rating [of a particular mode or activity] is not merely about the percentage or amount you learned, but how well it helped you to learn the concept/topic at hand." The learning activities in the study represented various modes of learning which primarily included active learning, service learning, problem-based learning, and case-based learning. In the previous work, the effectiveness of each learning mode was obtained by surveying each student on the self-reported amount learned and on the degree to which each class experience was interesting or engaging.

The survey is seen in Appendix A and in the initial publication for this research[6]. A 5-point Likert scale was used in the rating system, providing the necessary quantitative analysis to determine the rank of *learn* (potential to convey concepts) and *like* (level of engagement) for each of the learning modes. As noted, the research focused on a first-year design course and results revealed a wide array of learning and engagement level combinations for the activities used in the course. Each mode was profiled with a *learn-like* designation using a correlation metric. It was not surprising that many of the learning modes in the *high learn/high like* quadrant touch upon multiple learning styles and those in the *low learn/low like* quadrant addressed only a limited scope of the students' learning styles. The options suggested for handling the *low/low* modes were to (1) eliminate the activity, (2) change nothing (3) alter the activity, or (4) present or package the activity differently. In this follow-up paper, it is now time to look at what was done about the lower scoring modes and to evaluate the results of the students' perspectives on these changes.

The objective of this work is to first show the impact of the responsive changes in the design course components, specifically in the *low learn /low like* quadrant –what we did about it and if/how it worked. This further emphasizes the importance of continual assessment in a course. Second, prior to this analysis, data had also been collected from the recent instructing faculty for this course on their personal *learn/like* opinions for each mode and on faculty predictions of how the students would respond from their learner's perspective. This document is seen in Appendix B. Restated, how well do we as educators know our students? Does it matter if we get it wrong? Results were evaluated to determine if (a) our prediction for an activity has any bearing on how the students rate a learning mode for *learn/like* and (b) if any apparent mismatch in what we think and what they rate exists. The expectation is that other educators may identify with these results, test their alignment for the benefit of their student population, and make valuable adjustments to course content.

## Review of Literature

**Learning Styles and Learning Activities.** Previous work by the authors describes how each of the learning activities were infused into a first-year Engineering Design course[6]. These activities related to the following recognized dimensions of learning styles presented by Felder and Brent[4]: (1) *sensing* (concrete, practical, oriented to facts) versus *intuitive* learners (conceptual, innovative, oriented to theory); (2) *visual* (pictures, diagrams, *etc*) versus *verbal* learners (written and spoken); (3) *active* (tries things out, works with others) versus *reflective* learners (learns by thinking through, works alone); and (4) *sequential* (linear, orderly, learns in steps) versus *global* learners (holistic, systems thinkers, learns in large leaps). There were over 20 learning modes assessed in both the student and faculty surveys. These modes have been described in detail in the previous papers[5,6], and are again summarized at the end of this paper. As such, a brief review of each learning mode that was surveyed in the design course –and its mapping to the above learning styles– is outlined for the reader's reference in Appendix C.

## Methodology

**Student Survey**. As previously stated, a dual-component survey was administered to multiple sections of the student population in the Engineering Design classes in the fall semester of 2006 and again to a subsequent freshman class in 2007 ($n$ = 232, $n$ =191 respectively). The survey was administered in class during the last week of the semester in each year. The rating section of the survey used a 5-point Likert scale and students were asked to rate various activities on the degree to which they helped them learn and how engaging or interesting they were. Not all of the activities were used by every Professor, in which case students were instructed to place an 'n/a'.

While Engineering Design sections are taught by individual instructors, the course is conducted with a team-planning approach. All three of the authors were involved in co-coordinating this course over the

semesters of interest. Team meetings were conducted for all instructors every two weeks throughout the semester. It was established that instructors of this course conduct the learning modes in a similar fashion. Accordingly, the results across the sections were combined to yield aggregate results for analysis.

As noted above, the instructions, format, and ratings are shown in the questionnaire page in Appendix A. In addition to the ratings for each of the learning modes offered, requests for 3 open-ended commentaries were posed on the reverse side of the survey:

***Comments on what is <u>not</u> effective in your learning process:***
***Comments on what <u>works well</u> for you in learning about and applying engineering methods:***
***<u>Suggestions</u> for improving learning methods and/or <u>ideas</u> for other class-related activities:***

## Results and Discussion

Presentation of the research findings will first review the comparisons between the results of the first survey, collected in 2006 and the subsequent ratings found in the second survey collected in 2007. The student results will be designated as such: 2006 and 2007 for *initial* and *follow-up*, respectively. Next, the analyses will concentrate on correlations concerning on how the faculty personally regard each of the learning modes, then on the faculty's predictions of the students' ratings.

**Student Survey**. The plotted results of the *Learn/Like* survey from the Fall semester 2006 are shown in Figure 1. The graph is divided into four quadrants with result discussions referring to *Learn/Like* pairings as: *High/High* for those activities that are perceived to be simultaneously most effective for learning and highly engaging, found in the upper right quadrant, *High/Low* for course components which the students attested was good for learning, but not very enjoyable or engaging found in the lower right corner, and *Low/High*, *Low/Low*, also referring to the corresponding *Learn/Like* scores in the upper left and lower left quadrants respectively.

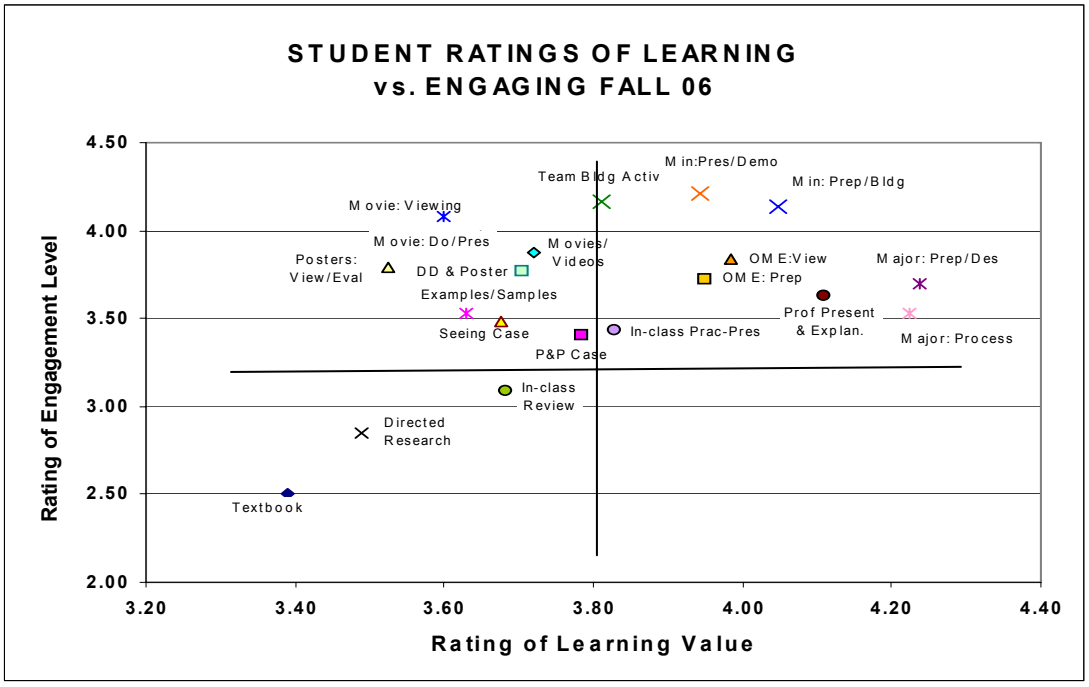


**Figure 1. Results of the Learn/Like Survey Fall 06 showing learning/engagement ratings for each learning mode.**

The following discussion reviews the *Low/Low* results and what was done in an attempt to move them into a higher quadrant.

**Review of Results on Low Learn /Low Engagement Quadrant**. The *Low/Low* cluster includes the *Textbook*, *Directed Research* and *In-class Review*. What do we do with the *Low/Low* modes? The initial thoughts are to (1) eliminate the activity, (2) change nothing (3) alter the activity, or (4) present or package the activity differently. These options will be discussed for each learning mode listed.

*Textbook*[10] is found at the lowest extremes on both continua at 3.4/5 in learning and 2.5/5 in engagement. The textbook is referenced, reviewed, and used in activities; but fundamentally –and not surprisingly– the students rated it low, just as they do in end-of-course evaluations. Although the textbook scores at the lower end, eliminating it is not an option as it has been agreed by the team of faculty that the textbook is of fine quality and contains necessary content and reference material for the course in an appropriate sequence.

*Directed Research* is also found in the *Low/Low* quadrant. This involves conducting patent searches, finding material to supplement case studies, and researching technical principles, and investigating product development outside the textbook. These activities do not inherently offer the uninitiated first-year student the prospect of stimulating and imaginative engagement, particularly if viewed in comparison to the construction of a specific project.

*In-Class Review* is the final learning activity found in the *Low/Low* quadrant. This typically involves devoting some class time to preparing and reviewing for exams. On reflection, mainly vocal students ask for this, but this does not necessarily reflect the needs of the majority. The feedback obtained suggests the prepared and motivated students neither want nor need this review.

**What Was Done.** The plotted results of the *Learn/Like* survey from the Fall semester 2007 are shown in Figure 2. As we review the results of our surveys from 2006 to 2007, we observed that although we had attempted to make some changes in order to move some items from low on the learn scale and low on the engaging scale, we found that many items changed, but only to a slight degree. Quantitatively, this change was less than 5%. Any significant movement beyond 5% was not in a positive direction.

We noted in the previous publication[6] that the three learning modes that fall into the *Low/Low* category – *Textbook*, *Directed Research* and *In-class Review*– all heavily target the verbal learner, and we described the learning style mismatch. Some suggestions to improve these activities involved connecting and integrating any of the indispensable low modes with the features of the more favorable modes. That paper also considered looking for opportunities to reach other learning styles such as the visual, active or reflective learner by using teaming, active matching exercises, or review sheets. For *Directed Research*, an emphasis on the importance of information gathering and how it relates to being a successful problem solver must be made. First-year students are prone to compartmentalizing and may not see the merit in such an activity as of yet, so that interest needs to be generated for them, along with utilizing other learning styles where possible in this activity. Each of the instructors made some adjustments in terms of handling of these three modes. For *In-class Review,* two out of three eliminated the mode.

For the *Textbook* and *Directed Research,* we clarified and revised the activities by tying them to the class more directly, emphasizing the importance in problem solving and providing feedback, such as the *Directed Research*. Nonetheless, there was not significant improvement. *In-class Review* was one mode that went down considerably. This year, it was conducted outside of class by only one instructor, and was optional. Some students reported that it was useful in identifying what they did not know, but it did not

move up in either direction. The *Textbook* and *Directed Research* just moved slightly lower, not a large enough change for concern.

Several items did move quite a bit lower on the learning scale and/or the engagement scale. These were *Movie Viewing*, *Posters Viewing* and *Evaluating* and *OME* (One-Minute Engineer)[8], both preparation and viewing. So after attempts to improve modes in the course, the ones that we deliberately tried to improve were not, and some that we did not change got worse. So what happened here, how do we explain this?

It can be noted that all of the modes are already at fairly reasonable levels. Even the *Textbook*, which has the lowest ratings, on average received an average rating over 2.7, and the other modes/activities range from 3.2 to 4.1. We can note here that there were a large number of modes that we did not adjust, and their ratings also went down. This is likely evidence of the general trait or attitude of students being more demanding or critical as a whole. We cannot have a control group in this experiment, but these are the same modes, implemented by the same instructors; what changes are the students, possibly their attitude characteristics.

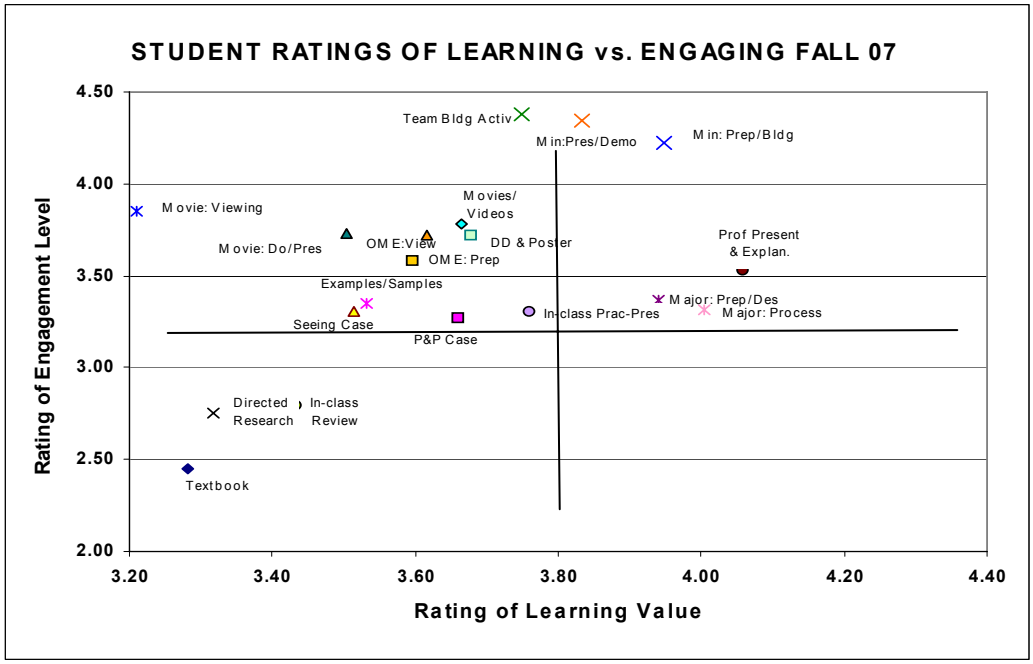


**Figure 2. Results of the Learn/Like Survey Fall 07 showing learning/engagement ratings for each learning mode.**

## Explanations for the Results

As we reflect, we can provide some insight into the outcomes started in the previous section. At the outset, we may have seen a small level of difference due to the fact that we surveyed a different group, but we will discuss other possibilities. There are factors that may have had some impact on the results from the students. Over the last several years, the instructors have been asked to add rigor to the course, which means that in any activity we are looking to mine it and change the focus to stress engineering rigor. This is accompanied by rigorous grading, being careful to evaluate fairly, but deliberately. This emphasis on rigor may be altering the activities slightly, and the instructors' attitude along with the students' perception. This may be an outside confounding factor, an unintentional change that may have created less excitement about certain activities. This can make it less engaging to the students.

Another factor is that we may unintentionally be less excited about each activity as its newness wears off. We try very hard to remember that it is new for each class, but it is challenging to maintain a high level of enthusiasm for years. And as we gain more experience with any activity, we provide "wisdom" to the students that may, in its delivery, seem less positive. This wisdom may sound like: "Be careful about doing this, I know you are tempted to do that, make sure you don't do this…"; this advice may not sound as positive as we did when we were more naïve. As the novelty wears off, we can easily become focused on the administration and organization of an activity. A good example of this may be the *Design Deconstruction* project. This requires a great deal of coordination and preplanning, and it is very easy for the instructors to be zeroing in on the details, instead of the significant benefits the activity yields.

In assessing this particular course, we can also note that extensive revision to the curriculum and learning modes used in the course and classroom has already been accomplished, resulting in a much improved course[5,6,12]**.** This was seen in increases in retention and significantly better course evaluation ratings in the categories of Overall Course, Instructor Effectiveness and Amount Learned in the course. In both of our surveys, most modes cluster in the high/high range, so we learned that engaging activities very often result in high perceived learning for the students, but shifting any modes so that they become more engaging or so that the students learn more may be difficult without revamping the activity in a much larger way. If a mode is *Low/Low*, as discussed above, these are also hard to move. It may be that we need to eliminate them, such as *In-Class Review*, or keep them, knowing that they are needed by the students, even if they do not appreciate them.

In some recent research[7], it was observed that the top five influences given by engineering students for effective lectures are (in order of importance to the students) 1) professor's positive interest or enthusiasm, 2) high engagement or active learning, 3) demonstrations or examples, 4) well-organized and structured class time, 5) high knowledge of topic by instructor. This positive interest influence has such a high degree of impact that even a small change in that may cause a downturn, and if the instructor is already enthusiastic, other changes to a mode may not change the level of that mode on either scale; i.e. being more organized has a smaller or even no impact on a mode.

Given that so much thought was placed into the course over the years, it appears that we need to be mindful about what really needs to be changed at this point. It may be apparent that whether a new addition is well received, or not, many of the existing modes used in the course may suffer from changes. We are not subscribing to the "If it ain't broke don't fix it" school of thinking, but if you have worked on it, it has improved and is at a good level, then it may be best to leave it there and just keep your eye on it. As in many pursuits, if you keep working something too much, it does not improve the quality but rather starts to muddy or compromise it –much like overkneading bread, or overworking a watercolor. There is a real possibility on some of the modes we have worked and reworked, that we have reached a point of diminishing returns.

Another possible factor is situational: First-year students are asked to provide a lot of feedback, not just to us, but to the College of Engineering as well. Therefore, they sometimes receive another survey with a groan. Some years there are so many questionnaires and evaluations packed in, that due to timing, we are burning the students out. Also, when the students are reviewing a long list of activities or modes, it is a natural outcome of the ranking process to rate some lower than others relatively, as all modes cannot score high. We conduct this survey at the end of the semester, when the emphasis is on their major design project. That may make some of the other modes that were done earlier in the course seem unimportant or less useful at that time. Also, in the second year of the survey the timing was such that it was done on the same day in addition to course evaluations and in some instances a third survey. There may be an effect of piling it on when we gave the survey the second time around, which was not the case in the first year.

**What Does Research Say?** Another question we asked ourselves was, "Has the population changed over this time period?" After reviewing some data on this population over the last few years, we do not see a quantitative change. We reviewed average SAT scores and average GPA's and neither have changed significantly, only a 2% increase in both scores from the previous year's study. In discussion with many colleagues who are looking at trends in student attitudes and thinking, there has been a much written about Generation Y and some of their characteristics. One of these is a sense of entitlement. There are many articles, editorials and blogs involving educators about this subject. The following quote casts some light on what is meant by this[11]

> *Walsh has worked with students with inflated egos and no sense of responsibility or respect. Too much self-esteem, he says, "creates a sense of entitlement. I'm not saying that children don't need reinforcement, but you have to make sure that you develop a realistic, practical, and consistent behavior plan." When we focus on building students' self-control, sense of belonging, and competence, we create more self-esteem than if we dole out constant praise. "Genuine self-esteem," says Shindler, is "a set of unconscious self-beliefs, formed over a lifetime, reflecting our perceptions and abilities, our ability to love, and how we attribute causality for the events in our lives."*

Another source states that educators have noted a steady decline in level of participation, level of interest and level of motivation in their students, paralleled by an increase in a sense of entitlement[1]. This sense of entitlement may be translated to a lack of responsibility and respect as seen in our students by them expecting that the teachers do more –include entertain– and that they do less, that we are then responsible for their learning, and they are not. This may then cause more criticism of the courses and the activities found within. "What did I get out of this?" in a personal sense, or "How is this useful to me right now?". We have instances from our classroom experiences of these types of changes. Many questions and comments we receive now respond with – "well you didn't show us or teach us that exactly", or "do I really need to know that, how will I use that". This requires us to be more detailed, more specific and spend time justifying each action or mode, possibly dampening our enthusiasm, which may also have a negative effect as seen.

The literature also documents the "customer service" model of higher education[2]. There are some that think that students and parents view themselves as customers or clients, and demand that we act like clerks or service representatives, not in a traditional faculty role. This model may also contribute to the way students perceive their instructors and create a different relationship, one in which the students are demanding satisfaction more than they had in the past. The discussions note that this is not necessarily how all students see the situation, and moreover that if we looked at it this way, we would improve "service". But there are some who think this attitude seeps into or even pervades our students and their parents, and this can negatively affect the nature of academia. One dissenting view[13] makes 13 points to show that this perspective has problems; the most compelling may be that "The delivery of education is a complex interaction of multiple systems that include students, professors, physical facilities, world events, time, and very complex social relationships. There is nothing neat about it. The conventional view of the customer is that such a complex set of systemic relationships should be minimized and streamlined as much as possible. Business does not want customer relations to be inefficient. "How does this tie in? We are using a fairly simple measure of one aspect of this complex process, that things like attitude shifts can confound results. That does not mean that we should not try to improve, or that we should forego assessment, but that at times we may have confounded results.

**Faculty Survey**. In agile education, it is critical to know whether we as faculty are hitting the mark with our students beyond the standard metrics of grades and retention statistics. Do our assessments match those of our students? If so, great; if not, in what areas and why not? We therefore extended the original

work, seeking to evaluate our multiple learning modes from both the learners' and instructors' perspectives by surveying both the student *and faculty* population on the learning potential of each mode and on the degree to which each course component or activity is deemed to be interesting or engaging. As noted, students responded for themselves by providing their ratings on learning and engagement for each class component. A similar survey was administered to 7 engineering faculty members in the fall of 2006 who teach multiple sections of the first-year design course. The first page of the survey was to "Rate *each* of the following learning activities on (a) the degree to which you feel they *can* help students in learning and (b) how engaging or interesting *you* think each is on a **1-5** scale" and the second page was to "Predict your students' ratings on (a) the degree to which *they feel* each activity helps them learn and (b) how engaging or interesting *they think* each is on a **1-5** scale".

Thus, the faculty responded for themselves providing (a) personal judgment and opinion on the learning and engagement value of each course component and also (b) predicted what the students' ratings would be on the two factors of learning value and engagement. This was done to better ascertain whether our first-year design course offers the opportunities to learn and connect that which we have envisioned for it.

The survey was administered prior to the student survey in order to prevent any biasing of the instructor's prediction of learning and engagement. The instructions, format, and ratings are shown in the questionnaire page in Appendix B. In relation to each of the learning modes used in the course, they provided feedback on two different facets of the course components: A two-part survey was distributed to current instructors and those from the recent past (< 5 years), all of whom participated in teaching the course under the coordinated-team format[12]. These two assessment areas, *personal faculty responses* and *predictive faculty responses*, will be addressed separately below.

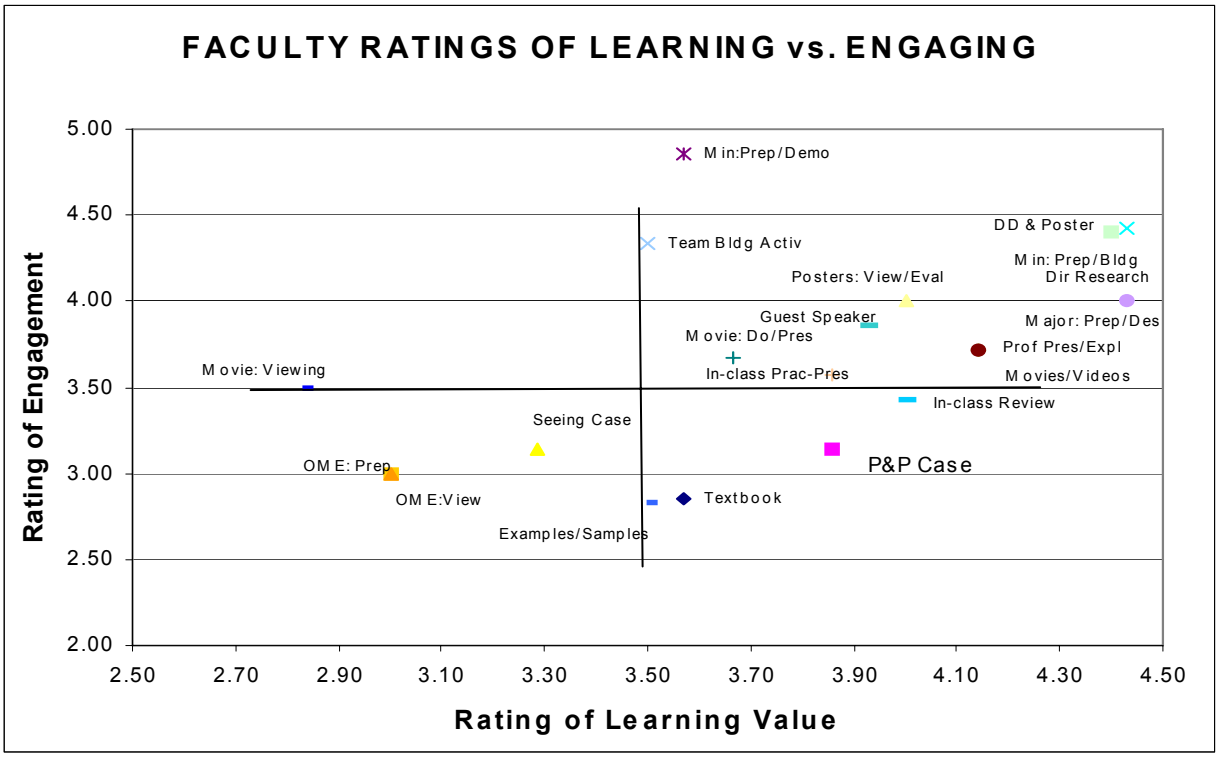


**Figure 3. Results of the Faculty Learn/Like Survey showing learning/engagement ratings for each learning mode.**

The plotted results of the *Learn/Like* faculty opinion survey from the Fall semester 2006 are shown in Figure 3 and the 2006 faculty prediction of student *Learn/Like* responses shown in Figure 4. The graphs are again divided into four quadrants with result discussions referring to *Learn/Like* pairings as described in the student survey results. An interesting result from Figure 3 is the clustering of learning activities in the *High/High* quadrant. It is clear from the graph that we as faculty perceive that most of what we do has high value –which goes without saying, why else would we do it? When looking at Figure 4, there is a shift for the cluster of learning activities from the upper right quadrant, *High/High* to the lower left quadrant, *Low/Low*. This indicates that our faculty expects lower ratings from the students on many of the learning modes.

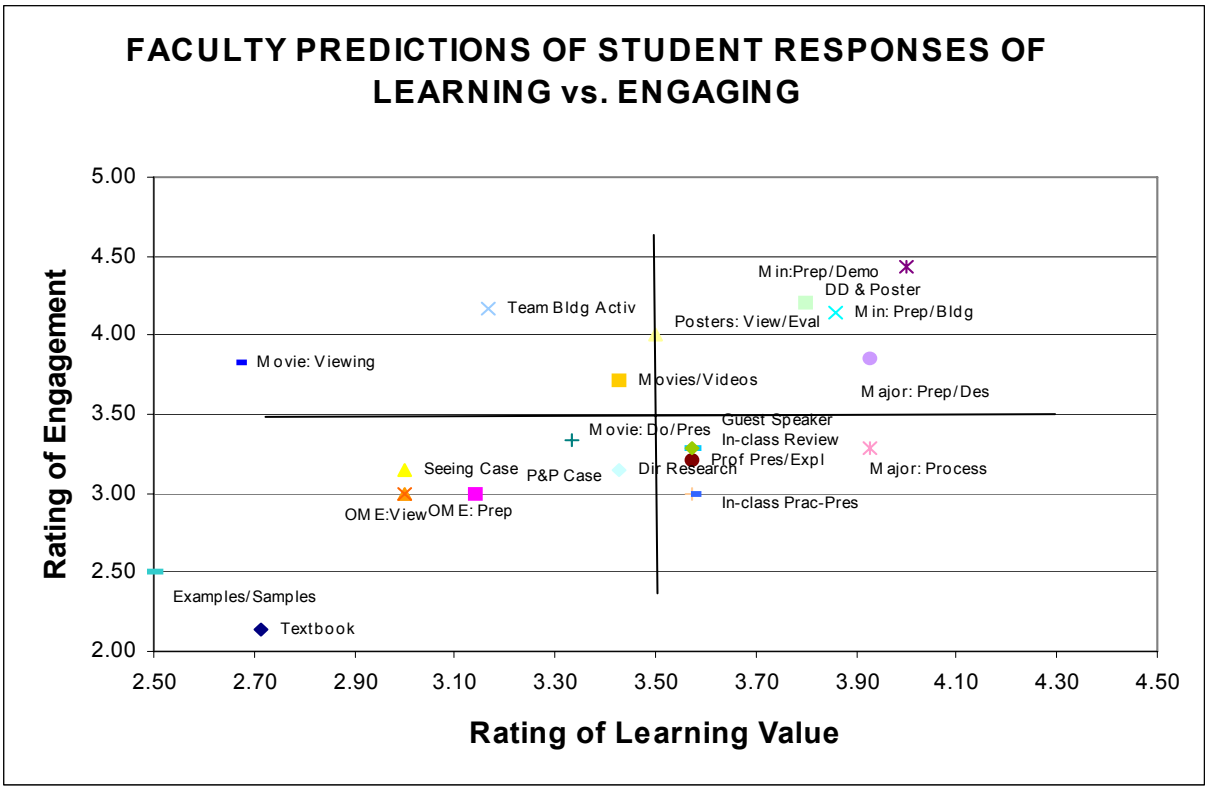


**Figure 4. Faculty Predictions of Student responses showing learning/engagement ratings for each learning mode.**

Figure 5 below offers a better view for a number of learning activities and shows the Faculty ratings and predictions as well as the average student survey results for both years. As shown on the graph, a pattern emerges. The faculty prediction is substantially lower than the actual student rating, but the faculty rating for that mode is higher than both of those. It appears that we underestimate the value the students give to these modes.

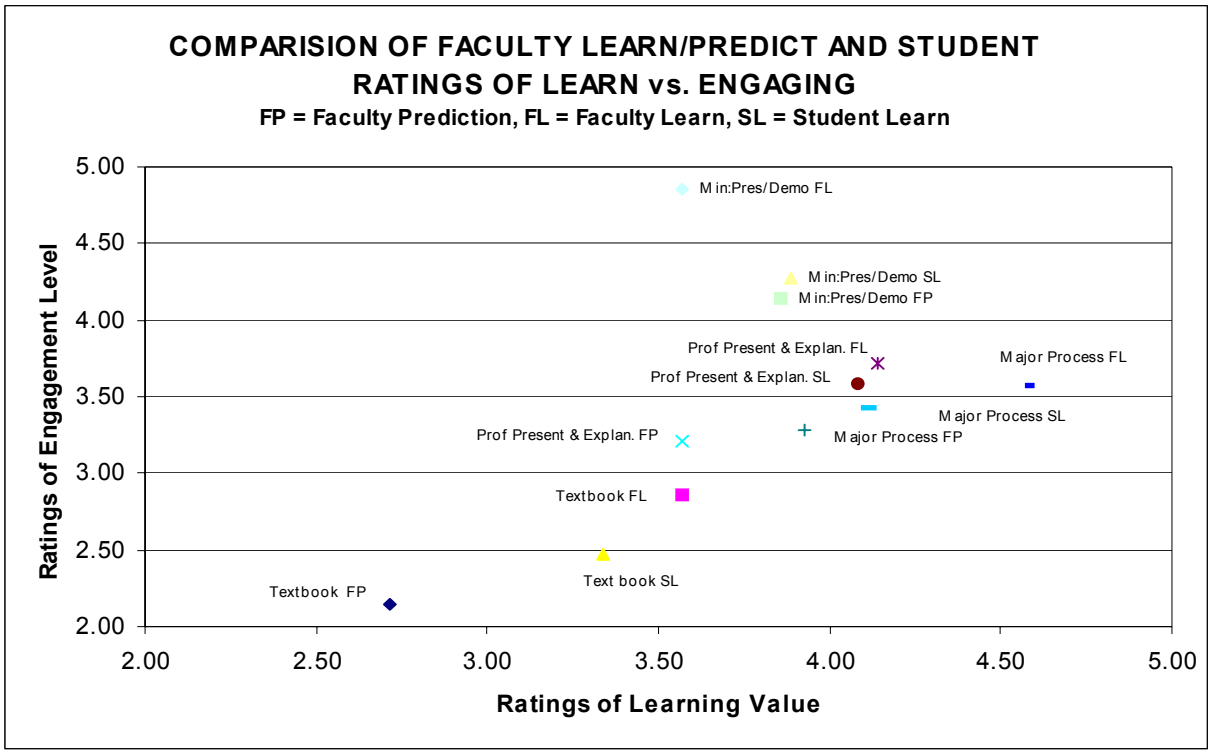


**Figure 5. Comparison of Faculty Learning / Predictions and Student Ratings for various learning modes.**

**Personal Faculty Responses.** Course instructors rendered their own opinions on the inherent learning potential and interest factor on each of the activities in the Engineering Design course they taught and the results are presented in Table a below. These responses were collected to reflect the faculty's personal thoughts about each of the learning modes they used in their course. An initial Pearson's product moment correlation analysis reveals a moderately weak overall correlation between the faculty's and students' opinions about the features of each of the learning modes (learn = 0.32, like 0.54). These are shown in the Original Correlation column in Table b. However, closer inspection reveals valuable information concerning the apparent disparity. Large mismatches occur only in the following areas:

- Students ratings of *One-Minute Engineer* activities were appreciably higher than those of the faculty.
- Students ratings of providing example work was higher that than of the faculty in the *like* category.
- Faculty have a notably higher opinion of *Directed Research*, *Guest Speaker* and the *Design Deconstruction* activity than the students did in both the learning value and engagement levels.

When the six areas in which there was a larger disparity are removed from the data and the correlation is recalculated on the remaining 15 modes, the results show that the personal faculty opinions actually do follow a profile comparable to those of the students, yielding much higher correlation values (learn = 0.76, like 0.82). These higher correlations represent a very encouraging outcome for us in that to some degree our opinions mirror those of the students, albeit we tended to underestimate the relative value of many of our learning modes as compared with our students.

**Table a. Student Ratings versus Faculty Personal Opinions for all Learning Modes in Engineering Design.**

| EDUCATIONAL VALUE: STUDENTS VS FACULTY PERSONAL OPINION | | | |
|---|---|---|---|
| Learning Mode | Students 06 & 07 | Faculty Self | Students - Faculty |
| Textbook | 3.34 | 3.57 | -0.24 |
| P & P Cases | 3.72 | 3.86 | -0.14 |
| Seeing Cases | 3.60 | 3.29 | 0.31 |
| Min: Prep/Bldg | 4.00 | 4.43 | -0.43 |
| Min: Prep/Demo | 3.89 | 3.57 | 0.32 |
| Prof Pres/Explan | 4.08 | 4.14 | -0.06 |
| Movie: Do/Pres | 3.58 | 3.67 | -0.09 |
| Movie: Viewing | 3.41 | 2.83 | 0.57 |
| Directed Research | 3.40 | 4.43 | -1.03 |
| In-class Review | 3.56 | 4.00 | -0.44 |
| DD & Poster | 3.69 | 4.40 | -0.71 |
| Posters: View/Eval | 3.31 | 4.00 | -0.69 |
| Team Bldg Activity | 3.78 | 3.50 | 0.28 |
| Major: Process | 4.11 | 4.57 | -0.46 |
| Major: Prep/Des | 4.09 | 4.43 | -0.34 |
| In-class Prac-Pres | 3.79 | 3.86 | -0.06 |
| Examples/Samples | 3.58 | 3.50 | 0.08 |
| Guest Speaker | 3.37 | 3.93 | -0.56 |
| Movies/Videos | 3.69 | 4.14 | -0.45 |
| OME: Prep | 3.77 | 3.00 | 0.77 |
| OME: View | 3.80 | 3.00 | 0.80 |

| ENGAGEMENT VALUE: STUDENTS VS FACULTY PERSONAL OPINION | | | |
|---|---|---|---|
| Learning Mode | Students 06 & 07 | Faculty Self | Students - Faculty |
| Textbook | 2.47 | 2.86 | -0.38 |
| P & P Cases | 3.34 | 3.14 | 0.20 |
| Seeing Cases | 3.40 | 3.14 | 0.25 |
| Min: Prep/Bldg | 4.18 | 4.43 | -0.25 |
| Min: Prep/Demo | 4.28 | 4.86 | -0.58 |
| Prof Pres/Explan | 3.58 | 3.71 | -0.13 |
| Movie: Do/Pres | 3.85 | 3.67 | 0.18 |
| Movie: Viewing | 3.96 | 3.50 | 0.46 |
| Directed Research | 2.80 | 4.00 | -1.20 |
| In-class Review | 2.94 | 3.43 | -0.49 |
| DD & Poster | 3.75 | 4.40 | -0.65 |
| Posters: View/Eval | 3.62 | 4.00 | -0.38 |
| Team Bldg Activity | 4.27 | 4.33 | -0.06 |
| Major: Process | 3.42 | 3.57 | -0.15 |
| Major: Prep/Des | 3.53 | 4.00 | -0.47 |
| In-class Prac-Pres | 3.37 | 3.57 | -0.20 |
| Examples/Samples | 3.44 | 2.83 | 0.61 |
| Movies/Videos | 3.83 | 3.71 | 0.11 |
| Guest Speaker | 3.35 | 3.86 | -0.51 |
| OME: Prep | 3.65 | 3.00 | 0.65 |
| OME: View | 3.78 | 3.00 | 0.78 |

**Table b. Original and Adjusted Correlations for Faculty Opinion vs. Student Ratings for Learning Modes**

| Correlations for Faculty Personal Opinion vs. Student Ratings for Learning Modes | | | | |
|---|---|---|---|---|
| FACTOR | Original Correlation | Adjusted Correlation | Adjusted Correlation: Items Removed for Low Matches | |
| Learning value | 0.32 | 0.76 | + | OME Preparation and Viewing |
| | | | - | Directed Research, DD Poster Activities, Guest Speaker |
| Engagement level | 0.54 | 0.82 | + | OME Preparation and Viewing, Examples of Student Work |
| | | | - | Directed Research, DD Poster activities, Guest Speaker |
| ***+ = students regarded as higher than instructor*** | | | ***– = students regarded as lower than instructor*** | |

**Predictive Faculty Responses**. As noted, the instructors also provided forecasts on how they believed the *students* would respond. How tuned in are we as educators? The resultant scores are presented in Table c below, with the correlation sets shown in Table d. The profile of our faculty forecasts of student responses in comparison to their actual predictions show a stronger match as compared with faculty opinions seen above (learn = 0.53, like 0.75) Again the students ratings tended to be higher than what the faculty predicted they would be. An identical approach was taken to identify large mismatches and then re-evaluate the correlation values with those eliminated.

- Students ratings for *One-Minute Engineer* activities were higher than those predicted by the Faculty.
- Students ratings of *Viewing Example Work* was higher than what the faculty predicted, learn and like.

The three areas in which there was a larger disparity between predicted and actual ratings were extracted from the data and the correlations were recalculated. Excepting those three modes, the results show that the faculty prediction also follow a profile similar to that of the students, yielding stronger correlation values (learn = 0.63, like 0.85). In this case again, we as faculty tended to underestimate the perceived value of many of our learning modes in terms of student ratings.

**Table c. Student Ratings versus Faculty Predictions of Student Ratings for All Learning Modes**

| EDUCATIONAL VALUE: STUDENTS VS FACULTY PREDICTION OF STUDENTS | | | |
|---|---|---|---|
| Learning Mode | Students 06 & 07 | Faculty Pred | Students - Faculty |
| Textbook | 3.34 | 2.71 | 0.62 |
| P & P Cases | 3.72 | 3.14 | 0.58 |
| Seeing Cases | 3.60 | 3.00 | 0.60 |
| Min: Prep/Bldg | 4.00 | 3.86 | 0.14 |
| Min: Prep/Demo | 3.89 | 4.00 | -0.11 |
| Prof Pres/Explan | 4.08 | 3.57 | 0.51 |
| Movie: Do/Pres | 3.58 | 3.33 | 0.24 |
| Movie: Viewing | 3.41 | 2.67 | 0.74 |
| Directed Research | 3.56 | 3.57 | -0.01 |
| In-class Review | 3.40 | 3.43 | -0.03 |
| DD & Poster | 3.69 | 3.80 | -0.11 |
| Posters: View/Eval | 3.31 | 3.50 | -0.19 |
| Team Bldg Activity | 3.78 | 3.17 | 0.61 |
| Major: Process | 4.11 | 3.93 | 0.19 |
| Major: Prep/Des | 4.09 | 3.93 | 0.16 |
| In-class Prac-Pres | 3.79 | 3.57 | 0.22 |
| Examples/Samples | 3.58 | 2.50 | 1.08 |
| Guest Speaker | 3.37 | 3.57 | -0.20 |
| Movies/Videos | 3.69 | 3.43 | 0.26 |
| OME: Prep | 3.77 | 3.00 | 0.77 |
| OME: View | 3.80 | 3.00 | 0.80 |

| ENGAGEMENT VALUE: STUDENTS VS FACULTY PREDICTION OF STUDENTS | | | |
|---|---|---|---|
| Learning Mode | Students 06 & 07 | Faculty Pred | Students - Faculty |
| Textbook | 2.47 | 2.14 | 0.33 |
| P & P Cases | 3.34 | 3.00 | 0.34 |
| Seeing Cases | 3.40 | 3.14 | 0.25 |
| Min: Prep/Bldg | 4.18 | 4.14 | 0.04 |
| Min: Prep/Demo | 4.28 | 4.43 | -0.15 |
| Prof Pres/Explan | 3.58 | 3.21 | 0.37 |
| Movie: Do/Pres | 3.85 | 3.33 | 0.52 |
| Movie: Viewing | 3.96 | 3.83 | 0.13 |
| Directed Research | 2.80 | 3.29 | -0.34 |
| In-class Review | 2.94 | 3.14 | -0.34 |
| DD & Poster | 3.75 | 4.20 | -0.45 |
| Posters: View/Eval | 3.62 | 4.00 | -0.38 |
| Team Bldg Activity | 4.27 | 4.17 | 0.11 |
| Major: Process | 3.42 | 3.29 | 0.14 |
| Major: Prep/Des | 3.53 | 3.86 | -0.33 |
| In-class Prac-Pres | 3.37 | 3.00 | 0.37 |
| Examples/Samples | 3.44 | 2.50 | 0.94 |
| Movies/Videos | 3.83 | 3.29 | 0.06 |
| Guest Speaker | 3.35 | 3.71 | 0.11 |
| OME: Prep | 3.65 | 3.00 | 0.65 |
| OME: View | 3.78 | 3.00 | 0.78 |

**Table d. Original and Adjusted Correlations for Faculty Predictions vs. Student Ratings for Learning Modes**

| Correlations for Faculty Predictions of Student Ratings vs. Actual Student Ratings | | | | |
|---|---|---|---|---|
| FACTOR | Original Correlation | Adjusted Correlation | Adjusted Correlation: Items Removed for Low Matches | |
| Learning value | 0.53 | 0.63 | + | OME Preparation and Viewing, Examples of Student Work |
| | | | - | None at a significant level |
| Engagement level | 0.75 | 0.85 | + | OME Preparation and Viewing, Examples of Student Work |
| | | | - | None at a significant level |
| *+ = students regarded as higher than instructor* *– = students regarded as lower than instructor* | | | | |

What can we learn from this? It is clear that improving the learning potential of *Directed Research* must come from presenting it differently -clarifying and revising the mode by tying it to the class more directly is not sufficient. It may need to be further connected in more than one way such as with activities like *One-Minute Engineer* in order for the students to see the benefit. Or we might have to accept the prospect that no matter how we try to change, it may always fail to engage the first-year student. The problem with the *Guest Speaker* might simply be a situational function of who they are and their personalities. We may perhaps have to work harder with the speaker to help with an agenda and ensure we are setting them up for success rather than letting them organize a talk which they imagine will be engaging –after all we supposedly know our students the best. On the other side of the spectrum, it is refreshing to see that an activity like *One-Minute Engineer* turns out better than expected. It would seem then that an activity done daily may lend itself to being perceived as important to the student as long as there is the opportunity to allow for imagination and ingenuity. Finally the higher *like* rating by the students would indicate that they learn by modeling others' work in *Examples and Samples*. There seems to be a "wow" factor and "we can do this too" when viewing past projects which was underestimated by the faculty. Some could find that looking at only the best examples of work might be intimidating and it is for this reason it is suggested to provide examples of "what not to do" as well.

In summary, the faculty predictions tended to be lower than the actual student ratings; it appears that we underestimate the value the students give to our multiple learning modes. This may be good news to all of us, indicating that the students give learning more value than we thought they did. But it also raises a concern as we appear to be underestimating their perception of learning value; we again confirm that the students are discerning and do place value on learning. Let us not underestimate their interest, their desire to learn and their ability to gain value from an activity. The faculty learning ratings show that we want more learning value in general than the students are telling us they retain. This is something we may have always known; there is always more to achieve, we will always want and hope that our students can and will learn more from the teaching modes we design. This keeps us always assessing, constantly trying, and continually improving.

**Conclusions.** The results presented here are part of an ongoing effort to assess and improve our first-year design course. We have surveyed students in order to determine which learning activities the students feel are interesting and whether they learn from them. With faculty, we have considered the same two fundamental components of each learning activity in addition to faculty predictions of what they think the student responses will be. Results from the faculty survey show that we as educators tend to place a high value on the learning activities chosen for our course while students tend to rate them lower in terms of engagement and learning potential. On the other hand our perception of how the students feel tend to be even lower than what they express. The student survey results indicate that our efforts to improve a course based on assessment information may reach the point of diminishing returns. With so much past effort made to improve the course, it appears that we now need to be attentive to what learning activities truly need to be changed. We must be conscious of the fact that things may not improve even if we put forth our best efforts. With this information we will continue as educators to test our alignment for the benefit of our students –however, we will be making adjustments to course content in a new light.

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# APPENDIX A:
## LEARNING MODES RATINGS PAGE FROM SURVEY ASSESSMENT TOOL

**Rate each of the following on (a) the degree to which they help you in learning and (b) how engaging or interesting each is on a 1-5 scale. Place n/a if it is not applicable in your class; Use a number for each option, 1=not at all; 5=very much You may use the same number twice since this is a rating, not a ranking.**

**The Learning rating is not merely about the *percentage* or *amount* you learned, but how well it helped you learn the concept/topic at hand.**

**The Interest portion is not merely about how *fun* the activity is compared to entertainment, but how engaging or interesting it is compared to other classroom teaching options.**

| *Not at all* | *Hardly* | *Somewhat* | *A Reasonable Extent* | *Very much* |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

| LEARN | | ENGAGE/INTEREST |
|---|---|---|
| _____ | *Engineering by Design* Textbook | _____ |
| _____ | Preparing and Presenting Case Studies | _____ |
| _____ | Seeing Case Study Presentations | _____ |
| _____ | Minor Design Project: Planning and Building | _____ |
| _____ | Minor Design Project: Preparing Demo and Demonstrating | _____ |
| _____ | Professor's Presentations and Explanations | _____ |
| _____ | Movie Analysis: Doing and Presenting | _____ |
| _____ | Movie Analysis: Viewing Presentations | _____ |
| _____ | In-Class Exam Review Activities | _____ |
| _____ | Directed Research Activities: (Internet, Patent Search, Site Visits, Interviews, etc.) | _____ |
| _____ | Design Deconstruction and Presenting Poster | _____ |
| _____ | Poster Presentations: Viewing and Evaluating | _____ |
| _____ | Teamwork/Team-Building Activities (Hanger Evaluation, Tower of Straws, Goals Consulting, etc.) | _____ |
| _____ | Major Design Project: The Process | _____ |
| _____ | Major Design Project: Preparing Presentation & Final Design | _____ |
| _____ | In-Class Practice ➔ Present Findings (Prob. Formulation, Goals Consulting, Abstraction & Synthesis, etc.) | _____ |
| _____ | Examples and Samples of Other Students' Work | _____ |
| _____ | Guest Speaker from Industry: Reebok® | _____ |
| _____ | Movies/Videos selected by the Professor | _____ |
| _____ | One-Minute Engineers: Preparing | _____ |
| _____ | One-Minute Engineers: Viewing | _____ |

bkj/sff/rw

*Thank you*

## APPENDIX B:
### FACULTY LEARNING MODES RATINGS PAGE FROM SURVEY ASSESSMENT TOOL

**Instructor:** _____ **Class:** _____

**GEU 110: Engineering Design**
**Learning Modes Questionnaire for Faculty**

**INSTRUCTIONS FOR SIDE 1: FACULTY PERSONAL ASSESSMENT ➔ ➔**

**The Side 1 Learning Modes rating is not merely about the *percentage* or *amount* you think students learn, but how much potential you believe it offers to help students learn the concept/topic at hand.**

**The Side 1 Interest portion is not merely about the level of *fun* the activity generates compared to general non-educational entertainment activities, but rather how engaging or interesting you personally think it is compared to other classroom teaching options/activities.**

***i.e., How do you feel about these teaching modes? Is it interesting to you as an educator to teach by this method?***

**INSTRUCTIONS FOR THE SIDE 2: FACULTY PREDICTIVE ASSESSMENT ➔ ➔**

**The Side 2 Learning Modes rating is not merely about the percentage or amount students can learn, but your prediction as to how *students* will respond to the activity and how well it helped them learn the concept/topic at hand.**

**The Side 2 Interest portion is not merely about how fun *the students think* the activity is compared to entertainment levels, but your prediction as to how *students* will respond or how engaging or interesting it is to them compared to other classroom teaching options.**

***i.e., How do you predict/expect the students will feel about and respond to each of these teaching modes? Whether or not a particular activity is interesting to you, do you believe it would be interesting to the students to learn by use of this activity, and what do you expect their rating of learning value will be?***

**SIDE 1 – FACULTY ASSESSMENT OF LEARNING MODES:** Rate *each* of the following on (a) the degree to which you feel they *can* help students in learning and (b) how engaging or interesting *you* think each is on a **1-5** scale. Write **n/a** if it is not applicable in your class. Use a number for *each* option, **1=not at all**; **5=very much.** You may use the same number twice since this is a *rating*, not a ranking.

| *Not at all* | *Hardly* | *Somewhat* | *A Reasonable Extent* | *Very much* |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

| **LEARNING POTENTIAL** | | **ENGAGING/INTERESTING** |
|---|---|---|
| _____ | *Engineering by Design* Textbook | _____ |
| _____ | Preparing and Presenting Case Studies | _____ |
| _____ | Watching Case Study Presentations | _____ |
| _____ | Minor Design Project: Planning and Building | _____ |
| _____ | Minor Design Project: Preparing Demo and Demonstrating | _____ |
| _____ | Professor's Presentations and Explanations | _____ |
| _____ | Movie Analysis: Doing and Presenting | _____ |
| _____ | Movie Analysis: Viewing Presentations | _____ |
| _____ | In-Class Exam Review Activities | _____ |
| _____ | Directed Research Activities:<br>(Internet, Patent Search, Site Visits, Interviews, etc.) | _____ |
| _____ | Design Deconstruction and Presenting Poster | _____ |
| _____ | Poster Presentations: Viewing and Evaluating | _____ |
| _____ | Teamwork/Team-Building Activities<br>(Hanger Evaluation, Tower of Straws, Goals Consulting, etc.) | _____ |
| _____ | Major Design Project: The Process | _____ |
| _____ | Major Design Project: Preparing Presentation & Final Design | _____ |
| _____ | In-Class Practice ➔ Present Findings<br>(Prob. Formulation, Goals Consulting, Abstraction & Synthesis, etc.) | _____ |
| _____ | Displaying Examples and Samples of Other Students' Work | _____ |
| _____ | Guest Speaker from Industry: Reebok® | _____ |
| _____ | Movies/Videos selected by the Professor | _____ |
| _____ | One-Minute Engineers: Preparing | _____ |
| _____ | One-Minute Engineers: Viewing | _____ |
| _____ | Other:_____ | _____ |

**SIDE 2 – FACULTY PREDICTION OF STUDENTS' LEARNING MODES RESPONSES:** Predict your students' ratings on (a) the degree to which *they feel* each activity helps them learn and (b) how engaging or interesting *they think* each is on a **1-5** scale. Write **n/a** if it is not applicable in your class. Use a number for *each* option, **1=not at all**; **5=very much.** You may use the same number twice since this is a *rating*, not a ranking.

| ***Not at all*** **1** | ***Hardly*** **2** | ***Somewhat*** **3** | ***A Reasonable Extent*** **4** | ***Very much*** **5** |
|---|---|---|---|---|

| **LEARN** | | **ENGAGING/INTERESTING** |
|---|---|---|
| _____ | *Engineering by Design* Textbook | _____ |
| _____ | Preparing and Presenting Case Studies | _____ |
| _____ | Seeing Case Study Presentations | _____ |
| _____ | Minor Design Project: Planning and Building | _____ |
| _____ | Minor Design Project: Preparing Demo and Demonstrating | _____ |
| _____ | Professor's Presentations and Explanations | _____ |
| _____ | Movie Analysis: Doing and Presenting | _____ |
| _____ | Movie Analysis: Viewing Presentations | _____ |
| _____ | In-Class Exam Review Activities | _____ |
| _____ | Directed Research Activities:<br>(Internet, Patent Search, Site Visits, Interviews, etc.) | _____ |
| _____ | Design Deconstruction and Presenting Poster | _____ |
| _____ | Poster Presentations: Viewing and Evaluating | _____ |
| _____ | Teamwork/Team-Building Activities<br>(Hanger Evaluation, Tower of Straws, Goals Consulting, etc.) | _____ |
| _____ | Major Design Project: The Process | _____ |
| _____ | Major Design Project: Preparing Presentation & Final Design | _____ |
| _____ | In-Class Practice ➔ Present Findings<br>(Prob. Formulation, Goals Consulting, Abstraction & Synthesis, etc.) | _____ |
| _____ | Examples and Samples of Other Students' Work | _____ |
| _____ | Guest Speaker from Industry: Reebok® | _____ |
| _____ | Movies/Videos selected by the Professor | _____ |
| _____ | One-Minute Engineers: Preparing | _____ |
| _____ | One-Minute Engineers: Viewing | _____ |
| _____ | Other:_____ | _____ |

# APPENDIX C:
## SUMMARY OF LEARNING MODES UNDER INVESTIGATION AND RELATED LEARNING STYLES

**Engineering by Design Textbook.** The textbook used is very similar to many other introduction to engineering and design textbooks currently available. The text is developed around the 6 phases of the design process outlined by Voland as: Needs Assessment, Problem Formulation, Abstraction and Synthesis, Analysis of Alternatives, Implementation and Reflection. The book uses many case studies to emphasize the engineering principles discussed in each chapter. Students are required to read and do selected homework assignments from each chapter. The textbook clearly benefits the verbal, intuitive and reflective learners.

**Preparing & Presenting Case Studies / Watching Case Study Presentations.** In these exercises, student teams are randomly formed and each team is given a historical topic or case study from the textbook to research and present. The presentation should contain a summary of the case, identification of the important lesson(s) learned concerning engineering design, and a similar example in which comparable principles are illustrated. This exercise reaches multiple learning styles: the sensor since it is oriented to fact, verbal because of the written and spoken words, active because of the teaming, and sequential because of the nature order of the process.

**Minor Design Project: Planning & Building / Preparing Demo & Demonstrating.** This first project is assigned early in the course to individual students or small teams. The same task is given to the entire class. They are to build and demonstrate a device of their own design. They experience the design process hands-on with a strong emphasis on the design steps of problem formulation, abstraction and synthesis, and implementation, with some iteration. There are multiple demonstration days, during which the students review others' projects and show the results of their own work. Some examples are: a pumpkin drop, ping pong ball launchers, mousetrap cars, and devices to wake up a roommate[9]. The opportunity is present for all learning styles to be reached. Sensors will benefit from seeing the physical fruits of their labor while intuitors are able to apply concepts, perform calculations, and innovate; visuals are able to diagram and draw whereas verbals and reflectors benefit from research and book reading; active learners get to work in teams and have a hands-on approach to the solution, while sequentials and globals are both covered through the nature of the design process and iteration.

**Professor's Presentations & Explanations.** This learning mode includes any material presented in the form of a lecture, PowerPoint presentation, written words, diagrams, or formulae on the board or on transparencies. This is also material presented and discussed with the professor who is moderating the class discussion. Students typically are required to take notes or download presentation summaries from the internet. Lecture formats will mainly benefit the verbal passive learner and perhaps the sequential learner.

**Movie Analysis: Doing & Presenting / Viewing Presentations.** In this assignment, teams of three or four students select and analyze a scene from a movie. They are looking to make the following points in their demonstrations, which should be accompanied by numerical analyses:

- What engineering principle was captured, applied, or represented?
- What part of that principle is correctly portrayed?
- What part of that principle may not be correctly portrayed?
- If the principle were to be corrected, what would it look like? Would it still be effective?
- How does this example portray engineers in society?

Student teams give a short overview to the class, showing their selected scene and related findings. This is another opportunity to have them research scientific principles, become dynamically engaged in public speaking, and practice organizing an effective visual presentation. This is an additional example of an exercise that reaches multiple styles of learning: the sensors since it is oriented to fact, intuitors because of the theory involved, verbals and visuals because of the written, spoken words, and diagrams or pictures used, actives because of the teaming and sequentials because of the natural order of the analytical process.

**In-Class Exam Review Activities.** Instructors use various methods to help students organize notes and reflect on past lessons learned in order to prepare for exams. This may include handing out review sheets, having students work on fill-in–the- blank or matching exercises, leading class discussions on important topics, and using other media such as PowerPoint, the overhead projector, or the blackboard to outline possible areas of assessment. The largest benefit would be realized by the verbal learner.

**Directed Research Activities: (Internet, Patent Search, Site Visits, Interviews, etc).** These activities involve research on case studies, or relate to the Major Design project (described below) and the problem formulation and analysis phase of the design process. Students must conduct an extensive literature and patent search relating to their design project topic. Other means of gathering information that is relevant to the project may include a site visit, conducting interviews with engineers or creating and executing a marketing survey. Students are required to organize and present this information in both a report and presentation at the end of the term. In much the same way as many of the other activities this will reach multiple learning styles depending on which is being performed. Verbal learners will do well with the written information and intuitive learners will be challenged with interpretations of concepts, calculations and theory.

**Design Deconstruction & Presenting Poster / Viewing & Evaluating Posters.** Student design teams deconstruct (reverse engineer) a product or device to understand how the design process was used, then prepare a poster presentation to be viewed by all first-year students. This course element has been added to (1) emphasize the details of production and manufacturing in product development, (2) demonstrate and capitalize on the effectiveness of using a poster session as a method for disseminating a large amount of information in a short period of time to a large population, and (3) provide students the opportunity to see what other student engineers have been doing. In addition, students are required to evaluate and comment on the posters in order to determine the "best" posters. Here the sensors, visuals, actives, and sequentials alike can do well with the concrete aspect, the diagrams or pictures involved, teaming and the deconstruction sequencing seen on the poster boards. Also an intuitive will benefit because of the theory involved; verbal and reflective learners will do well with the written report.

**Teamwork/Team-Building Activities: (Tower of Straws[3], Goals Consulting, etc.).** Activities such as Tower of Straws and Goals Consulting can be used as teambuilding exercises that demonstrate various phases of the design process. For example, in the Tower of Straws exercise the instructor divides the class into groups of 4-6 students. Each group is given 25 straws, a pile of paper clips and a small wad of modeling clay. The instructions are to build the tallest structure in 20 minutes using the materials provided. Some additional criteria used as goals are: most creative, earthquake resistant, hurricane resistant, and aesthetically pleasing. The class discusses the comparison to a real-world scenario in which they would have resource and time constraints, and must work as a team. This activity covers all design phases in an abbreviated manner: needs assessment, problem formulation (setting goals), synthesis, analysis, and implementation[21]. Additionally, once the towers have been built, there is also reflection on how the task and approach may have been revised. These activities always have a reflective component

which will benefit the reflective learner. In many instances there is opportunity to try things out to deduce, which will benefit the active and intuitive learner.

**Major Design Project: The Process / Preparing Presentation & Final Design.** This is assigned immediately after the Minor Design project has been completed and requires more thorough exploration of each engineering design step. It is coordinated with a more advanced and in-depth presentation of each design phase outlined in the textbook and in class. The course requires students to select and develop projects that are humanitarian and service-based. Students compile a number of intermediate assignments to create a final design report then present their findings in an end-of-the-term design presentation to the class. Students are given the opportunity to role-play investing in each others' design as well as to rate one anothers' presentations for design creativity, organization, and practicality. As with the Minor Design project, there are opportunities for all learning styles to be addressed. Sensors will benefit from seeing the results of their work, while intuitors are able to apply concepts, perform calculations, and innovate; visuals are able to draw, diagram, and prototype whereas verbal and reflector types benefit from research and resource reading; active learners get to work in teams and have a hands-on approach to the solution; sequentials and globals are both covered through the nature of the design process and iteration.

**In-Class Practice ➔ Present Findings (Problem Formulation, Goals Consulting, Abstraction & Synthesis, etc.).** Many of these activities are done to emphasize the day's lecture topic. Most use only 15 to 20 minutes of class time and are used throughout the course to relate to each of the design phases discussed in the textbook section above. Activities include using problem formulation techniques such as Duncker Diagrams, Kepner-Tregoe Problem Analysis, Kepner-Tregoe Situation Analysis, and Statement-Restatement Technique on current events. Numerous creativity stimulation techniques are used like brainstorming, bionics, checklisting, synectics, analogies, adaptation, fresh perspective, inversion, brainwriting, morphological charts, and idea diagrams. Others include techniques on Decision Analysis, for example using the Kepner-Tregoe Decision Analysis or Rank-Order Matrix to select an appropriate solution to a problem.

In the Goals Consulting session, design teams role-play as clients and consultants in relation to their Major Design Projects. The client team describes their design problem to the consultants who then outline a list of goals they perceive for the project, suggests the necessary background knowledge, and recommend the patent search keywords. The consultant team's suggestions are then compared to those already established by the client team. Often new ideas and viewpoints emerge for the clients in each case, leading to a richer approach to the problem at hand. As with the previous list of in-class activities each of these by design will have a reflective component which will benefit the reflective learner. The active learner will benefit from the hands-on nature and teamwork while the intuitive learner will have the opportunity to try concepts; the sequential learner will be able to follow a logical progression to form a conclusion.

**Displaying Examples & Samples of Other Students' Work.** Instructors may decide to show examples of past work to help current students understand what is expected of them in order to achieve the highest standard. This will include samples of both recommended and less preferred ways to approach the management of material. It is used prior to assignments being due and as reflection of previously submitted work. This is most suited for the verbal and reflective learner, but any student who learns by example can benefit from seeing models.

**Guest Speaker from Industry: Reebok®, Philips®, etc.** Students are exposed to various speakers from industry to provide fresh perspectives on engineering topics discussed in the classroom. Speakers

typically bring in a product and demonstrate its functionality while taking the students through the design process. As with a traditional lecture-based course, the verbal learner will benefit the most but sensors will appreciate handling the physical models and sequential learners can more easily follow a product's process from prototype to market once real-world context is provided by the visitor.

**Movies/Videos selected by the Professor.** Here students view films on selected engineering topics. For instance a film on the Wright Brothers' Flyer introduces the students to the design process. The Nova special "Battle of the X-Planes" looks at two companies trying to meet the same design goals from two vary different approaches and emphasizes the importance of proper analysis and dealing with design tradeoffs. Another is a film which presents engineering disasters that often have resulted in the loss of life and property and diminished engineering credibility. Homework associated with each varies from answering question about the topic to more in-depth analysis and further class presentations. For example in the disasters movie each Major Design Project team is assigned one of the disasters and then required to further research the technical and ethical issues that were involved. They summarize any product liability cases that arose out of the disaster and provide an example of a similar type of disaster and liability case. This exercise brings ethics and product liability into their analyses and provides each Major Design team the opportunity to present together for the first time before having to present their final design projects at the end of the term. Movies help both the visual and verbal learners through pictures and diagrams as well as the spoken word, respectively. In addition, active learners will benefit from the teamwork and reflectors from writing the reports.

**One-Minute Engineers[8]: Preparing / Viewing.** This activity gets the students involved in their own learning by having them explore their surroundings and find an engineering topic to present to the class. Each student has approximately one minute to start design class each day with a presentation on a device, a person, a concept, a vocabulary term, or a historical or current event related to engineering. This exercise will benefit the verbal learner but also allows for self-directed study which will benefit the reflective learner. Since visuals and physical models have been recommended –and are now required– a higher percentage of sensors and visual learners can be accommodated with this format.